THE IN-PLACE POLLUTANTS PROGRAM

VOLUME V, PART B

BENTHIC INVERTEBRATE STUDIES

RESULTS.

Prepared by: Rein Jaagumagi

for

Ontario Ministry of the Environment

Water Resources Branch

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CONTENTS

1. INTRODUCTION

The Great Lakes have been the subject of intensive study for many decades and a wealth of information now exists on many aspects of these water bodies (Cook & Johnson 1974; Minns et al 1986). For almost as long, the collection and analysis of benthic invertebrates has provided valuable information relating to the environmental conditions in the lakes (see for example, Brinkhurst et al 1968 and Kinney 1972). In many cases, e.g. Lake Ontario, these studies have provided a record of anthropogenic changes imposed on the lake (e.g. Warwick 1980).

Extensive benthic surveys of several areas in the Great Lakes system were carried out during the fall of 1985, under the direction of the Ministry of the Environment, Aquatic Biology Section, as part of its In-Place Pollutants program (background and purpose of the study are provided in Part A of this report). These areas included St. Marys River, Penetang and Midland Bays in Lake Huron, St. Clair River, Detroit River, Niagara River and Port Weller Harbour, Oakville Harbour, Toronto Waterfront and Bay of Quinte in Lake Ontario. The present report attempts to relate the physical and chemical nature of the habitat, with the distribution and ecology of the benthic fauna.

2. METHODS AND MATERIALS

The physical and chemical parameters presented in this report have been condensed from much more extensive data and include mainly those parameters known to affect the distribution, density, and community structure of aquatic invertebrates. Data were supplied by the Ministry of the Environment, and the chemical laboratory and sediment sampling methods have been documented elsewhere (Persaud et al 1987).

Throughout this report, reference is made to M.O.E. guidelines. The guidelines referred to are those for the open-water disposal of dredged materials (Persaud & Wilkins 1976). For the parameters listed in this report, the guidelines are:

Loss on Ignition	- 6.0%	Phosphorus	- 1.0 mg/g
Total Organic Carbon	- 10 mg/g	Copper	- 25 ug/g
Chromium	- 25 ug/g	Mercury	- 0.3 ug/g
Iron	- 10000 ug/g	Zinc	- 100 ug/g
Solvent extractables	- 1500 ug/g	Arsenic	- 8 ug/g

Benthic samples were collected from 110 stations in 10 major areas within the Great Lakes during October and November of 1985. The regions sampled were: Lake Huron in Midland Bay (10 stations) and Penetang HArbour (10 stations); St. Marys River (10 stations); St. Clair River (10 stations); Detroit River (10 stations); Niagara River (8 stations); Lake

Ontario at Port Weller (6 stations), Oakville Harbour (9 stations), Toronto Harbour and Waterfront (27 stations) and Bay of Quinte (10 stations). An additional 8 stations were sampled in the St. Clair River in October, 1986 as a follow-up to the 1985 study.

Benthic samples were taken with a 9 in.x 9 in. (22.9 cm x 22.9 cm) Ponar grab sampler. Three replicates were taken at each station (exceptions where noted), each of which was a composite of 5 Ponar grab samples. Samples were field washed using a U.S. 30 mesh (approximately 600 um) sieve and the remaining residue was stored in 5-10% neutralized (with Borax) formalin. The volume of each sample was noted as a percentage of the amount of material in the Ponar.

All replicates were later sorted, the specimens identified to ordinal level, and enumerated, in the laboratory. Large samples were subsampled where necessary. Subsampling was done by dividing the washed sample into a number of sections on a grid, from which subsamples were chosen at random. All specimens removed from the samples were stored in 80% ethanol.

The densities of organisms were averaged over the total number of replicates and the replicate closest to the mean values was chosen for detailed identification of the organisms present. The remaining samples were set aside for biomass determination.

Identifications were made using the most recent taxonomic literature available and the species lists reflect the most recent systematic treatments for each order. The major taxonomic works for the organisms present included:

Oligochaeta	-	Brinkhurst 1986
Chironomidae	-	Oliver & Roussel 1983
	-	Wiederholm 1983
Trichoptera	-	Wiggins 1977
Ephemeroptera	-	Edmunds, Jensen & Berner 1976
	-	McCafferty 1975
Amphipoda	-	Bousfield 1958
Gastropoda & Pelecypoda	-	Mackie et al 1980

Identifications were made to the lowest taxonomic level (species where possible, genus otherwise) and the numbers of each enumerated. Oligochaetes and Chironomidae were first mounted and cleared in polyvinyl lactophenol. Where large numbers of oligochaetes were present in a sample, a random subsample was made and approximately 50 worms were mounted and cleared. No effort was made to choose only mature worms and thus bias the interpretation of the community structure.

The community structure that emerged from these species lists was analyzed on the basis of equations derived from information theory. Species diversity (H') was analyzed using Shannon's formula (Calder et al. 1977);

$$H' = -\Sigma p_i \log_2 p_i$$

where $pi = \underline{ni}$ or the proportion of the sample belonging to the ith species.

Species richness was calculated using the formula;

$$SR = \frac{S-1}{\ln N}$$

where S = number of species
and N = total number of individuals (not per m2).

This equation measures the distribution of the individuals among the species present. Low values of SR denote a community in which most of the individuals fall into only a few species, while high values indicate that those individuals present are distributed over a wide range of species.

The distribution of individuals among species, here termed Evenness, was measured by;

$$J' = \frac{H'}{\log 2S}$$

where H' is the species diversity
and S = number of species.

Evenness is a measure of the dominance of the community by one or a few species. The greater the degree to which a community is dominated by a small number of species, the closer J' is to 0.

It must be stressed that indices such as those listed above are not absolute measures of the well-being of an aquatic community but are relative ones. They are most satisfactorily used to compare areas that are similar in physical characteristics. Where areas to be compared differ significantly in physical features (a rocky wave-washed beach as compared to a profundal depositional zone), their use is severely limited since substrate and depth preferences among benthic invertebrates as well as productivity differences within the substrate can play major roles in determining the species composition and density.

Analysis of the species composition (in broad terms, the presence of certain species and often, the characteristic absence of others) and the relative densities of those present, form the basis of community structure analysis. This method of data interpretation takes as its foundation the classical ecological definition of a community as consisting of a few species which are commonly distributed and present in greater densities, and a larger number of species that are sparsely distributed and relatively rare (Odum 1966). In a natural state such a community exists as a balance between these two groups. Under environmental stresses the natural balancing mechanisms are disrupted and an unnatural, stress-defined community or assemblage of species is favoured (Hynes 1960, 1970).

The analysis of functional feeding groups considers the ecological role that each species plays in the habitat. These roles are defined on the basis of the trophic levels, and hence the energy sources the various members of the aquatic community utilize. Merritt et al (1984) have identified six major groups of aquatic invertebrates on the basis of their feeding behaviour and these are listed in the left-hand column of Table 2.1. The major groupings are further subdivided according to food particle size and feeding mechanism. For example, Collectors, all of which feed on fine particulate organic matter (FPOM), are subdivided into two groups, the filterers, or suspension feeders, and the sediment feeders, though due to the nature of this food type both are still considered detritivores. In fact, in standing water habitats, the majority of the benthic fauna not associated with attached vegetation is detritivorous by nature of the fine sediments which constitute the greatest organic fraction of their environment. The substrate type can therefore predetermine, or at least strongly influence, the type of fauna that can exist in any particular area (Minshall, 1984). This has been very nicely demonstrated most recently by Johnson et al (1987) who found a strong correlation between sediment organic content, and to a lesser degree, sediment texture, and the distribution of benthic invertebrates.

It should be noted that most detritivores, while they may ingest a variety of substances, actually digest out only a few usable parts, most often the microorganisms associated with the breakdown and decay of organic matter. Thus, while oligochaetes feed by ingesting sediment, they digest out only the micro-flora and -fauna and some of the richer organic fraction (Brinkhurst & Austin 1979).

Aquatic vascular plants by contrast, provide a variety of potential food sources. These include not only those organisms feeding directly on the plant tissues themselves, but also those feeding on algae and other microorganisms growing on the plant, as well as seston that settles on the plant surface (Lamberti & Moore 1984).

The variety of feeding categories present, as well as the variety and types of organisms present in each category, provide valuable clues to the well-being of the community as a whole.

Biomass estimates were calculated as preserved wet weight of organisms. Samples were blotted dry on filter paper to remove surface moisture and were immediately weighed to the nearest 0.1 mg on a Mettler H20T balance. The results were averaged over the number of replicate samples and the mean value has been presented in the tables. According to both Landahl & Nagell (1978) and Wiederholm & Ericksson (1977) this method gives reasonable reproducibility. Samples were preserved for a minimum of 21 days in 80% ethanol before weighing.

Landahl & Nagell (1978) indicate that a correction factor of 10-12% is necessary for ethanol preserved specimens to account for differences in density between ethanol and water. This is required since during preservation the water content of the organism's body is replaced with the preservative.

Wiederholm & Ericksson (1977) found a much smaller weight loss for chironomids than did Landahl & Nagell, as well as a larger weight loss for oligochaetes. According to their studies, oligochaetes lost an average of 16% of their fresh weight after two months in ethanol, while chironomids were found to have lost only 4% of fresh weight. It would appear that preserved weight biomasses are quite close to actual fresh weights of the organisms. Because of these differences among the various organisms, no individual corrections were made to the data in this report. Rather, a total preserved weight is given and a corrected (10% added) total biomass has been calculated from this. The heavy preponderance of oligochaetes in most of the samples indicate that 10% is a reasonable compromise between the results of Landahl & Nagell and those of Wiederholm & Ericksson.

The biomass values obtained for the stations sampled during this survey will likely be low estimates. Growth rates and, particularly for insects, the overwintering instar are major variables relative to the season of sampling. Both Winnell & White (1985), in their study of chironomid species in the Great Lakes, and Kennedy (1966), in his studies of the oligochaetes, note that late-fall, early-winter (November-December) are the least productive months for most of the common species. Winnell & White (1985) have shown that during this period, density of individuals is lowest among the common species of _Cryptochironomus_, _Chironomus_, and _Polypedilum_, all of which were well represented and often made up a considerable proportion of the benthic fauna at most localities in this survey.

Comparisons of the data from this survey with other published surveys, especially those where sampling was conducted during the pre-emergence spring peak in biomass, will therefore show net decreases in biomass. It must be borne in mind that much of this change is a sampling artifact and should not be interpreted, except where severe, pronounced changes have occurred, as evidence of environmental stresses. Unfortunately, any subtle changes that may have occurred as a result of such stresses will likely be masked by this factor.

At the few stations where unionid clams were present a weight including and excluding these has been presented. The reason for excluding them is to facilitate in comparison of biomass figures among stations. This was necessary since only a few stations yielded any large clams in the samples.

Finally it is important to make some distinction between the terms eutrophic and organically polluted as used in this report. While it is true that organically polluted areas are almost always eutrophic, eutrophic areas are not necessarily organically polluted. The difference is a matter of degree.

The term eutrophic refers to areas that are augmented in terms of organic content, and these areas are, as a result, generally much more productive (Wetzel 1975). They, in turn, support a variety of organisms that utilize this increased organic matter. As a consequence, eutrophic

areas tend to support a wide variety of often characteristic organisms, and usually in considerable densities. Naturally eutrophic areas are generally found in shallow protected bays where organic matter (usually allochthonous) accumulates.

Areas considered organically polluted contain very high levels of allochthonous, usually anthropogenic, organic matter. Levels are often so high that oxygen deficits in the overlying water column result through aerobic decomposition of the organic matter. This in turn results in the elimination of those aquatic species requiring high oxygen levels to sustain respiration and hence metabolism. Consequently only a very reduced fauna, comprised of those species able to tolerate low oxygen levels, remains in these polluted areas. These, depending upon organic levels, can increase significantly in density and become the dominant, and often only, fauna present, at levels that far exceed the density of the original fauna. Characteristic of these types of communities are oligochaetes, usually the species Tubifex tubifex and Limnodrilus hoffmeisteri. Both of these species thrive in these areas simply because of the low levels of oxygen at which they are able to exist. In eutrophic areas they form a smaller part of the fauna, mainly because they are considered as rather poor competitors in natural situations (Kennedy 1965).

TABLE 2.1. GENERAL CLASSIFICATION OF AQUATIC INVERTEBRATE FUNCTIONAL FEEDING GROUPS.

Functional Group	Subdivision of Functional Group: Dominant Food	Subdivision of Functional Group: Feeding Mechanism
Shredders	Living vascular hydrophyte plant tissue	Herbivores -- chewers and miners
	Decomposing vascular plant tissue and wood -- coarse particulate organic matter (CPOM)	Detritivores -- chewers, wood borers, and gougers
Collectors	Decomposing fine particulate organic matter (FPOM)	Detritivores -- filterers or suspension feeders
		Detritivores -- gatherers or deposit (sediment) feeders (includes surface film feeders)
Scrapers	Periphyton -- attached algae and associated material	Herbivores -- grazing scrapers of mineral and organic surfaces
	Living vascular hydrophyte cell and tissue fluids or filamentous (macroscopic) algal cell fluids	Herbivores -- pierce tissues or cells and suck fluids
Piercers	Living animal tissue	Carnivores -- attack prey and pierce tissues and cells and suck fluids
Engulfers (Predators)	Living animal tissue	Carnivores -- whole animals or parts)
Parasites	Living animal tissue	Internal parasites

(Modified from Cummins (1978))

3. LAKE ONTARIO

3.1. TORONTO WATERFRONT

Introduction

The Toronto Harbour and Waterfront have been identified by the IJC as one of the 38 Areas of Concern where contaminated sediments are a major problem (I.J.C. 1987). Historically, the waterfront has received wastes from a number of industrial and domestic sources, located not only along the waterfront, but also along its two major inflows, the Humber River and the Don River. Both have added to local pollution problems by transport and deposition of contaminants from upstream sources. At present, these continue to add to the sediment contaminant burden by addition of new material, as well as effecting a certain measure of redistribution of historic material. In addition, domestic and industrial sources along the waterfront, as well as lakefill projects that use contaminated sediments, provided inputs of contaminants and organic matter.

Gregor and Rast (1982) characterized the Toronto Harbour and waterfront as eutrophic on the basis of their Composite Trophic Index. Analysis of the sediments, as well as analysis of the benthic fauna, showed this to be the case throughout the areas sampled.

3.1.1. TORONTO HARBOUR

Water Quality

The waters of Toronto Harbour can be characterized as hard water of high pH (Table 3.1.1). Organic content (as denoted by levels of COD and DOC) was moderate to high (stations 1379 and 1363) and the waters were, for the most part, moderately clear and low in suspended matter. The most significant exception was station 1363, which had a very high suspended load and hence very murky conditions. Salts (Na and Cl) were also moderately high at most stations.

Sediment Quality

The sediments along the northshore, stations 1346, 1360 and 1379, yielded high levels of hydrocarbons (solvent extractables, Table 3.1.2) PCBs, pesticides, as well as most of the metals, and in fact most of the parameters measured exceeded M.O.E. guidelines. Station 1346 (Fig. 3.1), located in an area of sand-silt substrate (45% and 37% respectively; Table 3.1.2) was moderately high in organic content (TOC = 50 mg/g; LOI = 6.7%). Levels of most contaminants exceeded M.O.E. guidelines by significant amounts, with levels of PCBs exceeding the allowable limits by nearly 32 times. Pesticides, specifically the chlordanes, endosulfans, and heptachlor epoxide, were the highest of any station in the harbour (M.O.E. unpublished data).

Station 1360, also located along the waterfront, was similar in many aspects to station 1346. Sediments were mainly silts (56%, Table 3.1.2)

though the clay content was also high (21%). Sediment organic content was moderately high as were most of the other chemical parameters measured. Overall, levels of many of the contaminants, such as hydrocarbons, Cu, Cr, As, and Zn were higher than at station 1346. In contrast, PCB and pesticide levels were significantly lower.

Station 1379, located at the mouth of the Keating Channel, was situated in an almost exclusively sandy area (95%), with only a minor amount of silt (4%). Organic content, however, was still moderately high (TOC = 26 mg/g). Levels of contaminants in the sediments were low, indicating the sandy sediments were not retaining these materials in the same way silts and clays appear to.

Located in deeper water in the middle of the harbour, station 1363 appeared to be situated in the main depositional area (Fig. 3.1). Suspended particle load and organic content of the overlying water were the highest of any station in the harbour (Table 3.1.1). Sediments were predominantly silts (64%), with a high clay content (31%), though organic content was low, indicating that much of the material that had accumulated here was in fact washed down from shallower areas. Contaminants were generally lower than at the north shore stations but were still significantly above the guidelines. Pesticide (chlordanes, DMDT methoxyclor, endosulfan sulphate) and PCB levels were also high.

Sediments at stations 1352, 1359, 1373, and 1367, all located in shallow areas along the shoreline of the Toronto Islands, were very different from stations along the northshore of the harbour. All four stations were characterized by sandy substrates (85%-95% sand), low in silt content, and very low in clays. Sediment organic content was very low at all stations, as were levels of most of the contaminants, all of which were well below M.O.E. guidelines (Table 3.1.2). This was to be expected since organic content has been found to be a major factor in affecting contaminant levels in sediments (Sigg et al. 1987; Mudroch & Duncan 1986).

Benthic Invertebrates

All three stations located along the Toronto Harbour north shore were more or less similar in the composition of the benthic fauna, and differed primarily in density of organisms. At station 1346, the benthic fauna consisted almost entirely of oligochaetes (99%) which were represented exclusively by the Tubifex tubifex - Limnodrilus spp. community. Brinkhurst (1970), in his 1969 survey, found these to be the most common species in this part of the harbour and attributed this fauna to the increased organic content of the sediments. The moderately high density and biomass (Table 3.1.3), and the large proportion of immature worms, indicated that the contaminants noted above had a relatively minor effect on the density of the oligochaete fauna.

Sediment fine particle feeders also comprised 99% of the fauna at station 1360. The only other species present was the oligochaete predator Procladius (Chironomidae). Conditions appeared unsuitable for other organisms, the most likely cause having been the high sediment organic

content, which would have placed a high oxygen stress on the organisms inhabiting this area. It is noteworthy that the benthic fauna was also considerably larger in both density and diversity than at station 1346, though the sediment fine particle feeders still formed over 99% of the fauna. The oligochaete community, while comprised mainly of the Tubifex tubifex - Limnodrilus spp. association, also contained a few other species as well (Table 3.1.4). Biomass was also much higher at this station and all these differences, taken together, seem anomalous in light of the increased levels of contaminants in these sediments.

Evans et al (1988) and Andrews (1987) have shown that at least some of the metals in organic sediments (Zn, Co,) are primarily (in the 80% range) held in the residual fraction and thus may be largely unavailable to benthic organisms. They also indicate that the availability of these may further decrease with decreasing sediment Eh, thus making contaminants in anoxic sediments more resistant to uptake by benthic animals. Recent work (Poulton et al 1988) has also shown that some of the metals (Cu, Cd, Mn, and Pb) reside in the organic fraction and it is these same contaminants that tend to reach their highest levels in fine-grained sediments (silts and clays) of high organic content. Since much of the infauna feed on these sediments, theoretically these would also be more available to benthic organisms. Of these contaminants, however, those that reside in the clay fraction would tend to be less available to benthic organisms, since few if any animals inhabit or ingest clay sediments (Hynes 1970).

The high organic content at these two stations would contribute to both of these factors, and this may have accounted for the large populations of oligochaetes that seemed to occur in spite of the high contaminant levels. The sediment feeding infauna, which includes the oligochaetes, have traditionally been considered to be most at risk from contaminants within sediments because of their rather indiscriminate ingestion of the sediments. Surface (epibenthic) species were generally considered to be less affected and surface predators to be affected least of all. However, recent studies (van de Guchte et al 1988; Beak 1987) indicate that the opposite may in fact be true in certain situations. Chapman et al (1982a, b) and Wiederholm et al (1987) both found that when sediments were introduced into bioassays, the toxic effects of some metals and organic compounds were reduced. Evans et al (1988) and Beak (1987) have both found that sediment pore water often contains a much larger bioavailable fraction of an individual compound or element than do sediments, mainly as a result of sediment desorption (reflux). Thus, epibenthic species may in fact be more likely to come into contact with toxic, or bioavailable, forms of these chemicals through surface absorption, than the infauna is through ingestion.

The fauna in areas where these metals have been found to accumulate is similar to that found in organically enriched areas, which implies that the same benthic community that is tolerant of organic pollution is also tolerant of these metals (to a certain threshold (Poulton et al 1988)). This was borne out at many of the stations in this study, where the typical organic pollution community was present in great density in conjunction with elevated levels of these metals (where other contaminant levels were

low).

Therefore, while little correlation seems to exist between sediment metal levels and aquatic invertebrate density (Poulton et al 1988), Beak (1987) noted that diversity was negatively, though not significantly, correlated with levels of certain organic pesticides. While Beak also found that certain pesticides correlated positively with density this is likely a spurious correlation. Beak (1987), indicated that many organic compounds, particularly hydrophobic ones (most of the organic pesticides), tend to accumulate in fine grained sediments. Since both these and benthic density are positively correlated with sediment organic content, it seems likely that the pesticides are in reality correlated with sediment organic content and not benthic organism density. Since levels of numerous pesticides were higher at station 1346 than at station 1360 (chlordanes, dieldrin, DMDT methoxyclor, endosulfans and related compounds, endrin, and heptachlor epoxide), some reduction in density of the fauna at station 1346 could well be due to chronic effects from these compounds. These results are consistent with those of Beckett and Keyes (1983), who found that both total density and diversity were reduced in areas receiving organic contaminants.

Station 1379, located in a sandy area at the mouth of the Keating Channel, was still high in organic content and this, in turn, supported the large community of sediment fine particle feeders, such as oligochaetes (which themselves comprised 99.9% of the fauna). Density and biomass of the oligochaetes was high (Table 3.1.3), and this fauna consisted almost exclusively of the _T_. _tubifex_ - _Limnodrilus_ spp. community associated with organically polluted conditions. Levels of contaminants in the sediments were low, indicating this area was not exposed to the same types of contaminants as were stations 1346 and 1360, or if it was, the sandy sediments were not retaining the materials in the same way silts and clays appear to.

Located in deeper water in the middle of the harbour, station 1363 appeared to be situated in the main depositional area of the harbour (Fig. 3.1). While suspended particle load and organic content of the overlying water were high, sediment organic content was low, indicating that much of the material that had accumulated here was likely washed down from shallower areas. The benthic fauna was almost exclusively sediment fine particle feeders, of which the sediment infauna comprised the major part (70%; Table 3.1.3). Sediment surface feeders, such as the clam _Pisidium casertanum_, were also significant (29%). _Procladius_, as the sole predator species, and _Asellus_, an epibenthic grazer, both present in very low densities, were the only other groups present. As at the north shore stations, the oligochaete fauna consisted primarily of the _T_. _tubifex_-_Limnodrilus_ spp. community characteristic of polluted areas.

Stations 1352, 1359, 1373, and 1367, were all located in shallow generally sandy areas along the shoreline of the Toronto Islands. The benthic fauna at these stations was typical of littoral areas, with high densities of amphipods (_Gammarus_ spp.), chironomids (in particular _Endochironomus_, _Cryptochironomus_, and _Chironomus_) and molluscs, of which

Pisidium spp. and Valvata spp. were the most common. Biomass values indicated these were all highly productive areas which compared well with other similar areas of the Great Lakes (Cook & Johnson 1974). Oligochaetes formed only a minor part of the fauna (max. 31.5% of Station 1357), though the species represented had changed little from other areas of the harbour (Table 3.1.4).

Station 1352 yielded the highest sediment silt and organic contents of these four stations (Table 3.1.2). Despite the high levels, oligochaetes comprised only 28.6% of the fauna, even though sediment fine particle feeders dominated the fauna (45% of the total density was comprised of oligochaetes, Valvata spp., Pisidium spp., and Glyptotendipes). The other major group was the epibenthic grazers associated with the micro-flora and -fauna which are the major decomposers of coarse detritus. This group, comprised of Asellus, Endochironomus dispar, and Gammarus fasciatus, made up 35% while predators, represented by the single species Cryptochironomus, comprised 18% of the total fauna. Thus, while a sizeable fraction utilized fine organic particles, at least half of the fauna did not and utilized instead, a more local source of energy, namely the coarse organic detritus so prevalent in littoral areas.

A similar situation existed at station 1359 where the epibenthic grazers, represented by the species Endochironomus and G. fasciatus made up 27% of the fauna. The higher percentage of sediment fine particle feeders (72%) implied a relatively lower amount of coarse organic detritus.

Station 1373, also in a mainly sandy area, yielded a more even distribution of the same assemblage of feeding groups. Grazers on coarse detritus made up 31%, while predators and sediment fine particle feeders comprised 11% and 58% respectively, though with no significant change in the species represented. Biomass was lower than the preceding two stations, mainly as a result of the reduced mollusc density.

Station 1367, with 68% of the fauna present as Gammarus lacustris indicated that macrophytes played a major role in defining the benthic composition, since this species is often found as grazers on microorganisms and seston on macrophytes. The lepidopteran Munroessa, a miner in aquatic plants, is also an indicator of the occurrence of macrophytes. Sediment fine particle feeders were common as well and represented 15% of the total faunal density.

In summary, three broadly defined areas were evident within the Toronto Harbour as based upon the benthic fauna. The first was a zone of organically enriched sediments along the waterfront, characterized by high densities of oligochaetes. Some improvement does appear to have taken place. Brinkhurst (1970) found densities of oligochaetes upwards of 250,000/m2 while the maximum recorded during this survey was 31,631/m2 at station 1360. Sediment organic content was much lower in the harbour than has been observed in areas where densities of 250,000/m2 to 500,000/m2 were recorded (see for example, Kam River data in Jaagumagi (1987)). Evidently, some decrease in organic content and therefore organic pollution has occurred since Brinkhurst's (1970) survey. While contaminant levels in

these same areas were high, they have apparently had little discernable effect on the oligochaete community, the only major benthic group in these areas.

As noted earlier, a correlation does exist between total benthic diversity and certain pesticides (Beak 1987). These contaminants could, also, be responsible for some reduction in benthic density in those areas where levels were high (station 1346), and could serve to limit future colonization of these areas by other organisms as sediment organic conditions improve. It appeared, however, that some of the other contaminants were not reaching the organisms and in those cases were likely present in a form unavailable to the benthic fauna. Other contaminants apparently had little effect on those species present, though these were mainly those already known to be tolerant of organic pollution. These species also seem to have a tolerance to certain of the metals.

A transitional area, represented by station 1363, also revealed a trend toward improved sediment conditions. Specifically, this was reflected in the increased diversity of feeding groups and a decreased dominance of the benthic fauna by high densities of oligochaetes. One of the most heavily polluted areas during the 1969 survey by Brinkhurst (1970), this area appears to have undergone some improvement since then.

The third zone, located around the Toronto Islands, was characterized by a diverse fauna, typical of shallow, eutrophic littoral areas of the Great Lakes. Sediment organic content was very low, as were contaminant levels, and the major factors determining benthic composition appeared to be depth, the occurrence of macrophytes, and the levels of detrital material.

3.1.2. TORONTO OUTER HARBOUR AND EASTERN HEADLAND

Water Quality

Water quality data (Table 3.1.5) indicated the areas sampled (Fig. 3.1) were predominantly hard water areas, of high pH, with moderate organic levels. Suspended particle load was variable and generally highest at the silty stations, reflecting the depositional nature of these areas.

Sediment Quality

Stations were located in a variety of habitats, ranging from protected bays to deepwater, open-lake areas. Sediments varied from silts and clays in the protected areas, to rock and gravel at those open lake areas subjected to current and wave action (Table 3.1.6). Organic content was low at most stations, as were levels of most contaminants.

Three stations were located in the Outer Harbour. Station 1389, located near the eastern entrance to Toronto Harbour, was situated in an

area of sediment accumulation. Sediments consisted primarily of silt (58%) and clay (24%), and were moderately high in organic matter (TOC and LOI, Table 3.1.6). Contaminant levels were only moderately high, though PCB levels were well above M.O.E. guidelines (9 times higher), and the highest of any station outside the Harbour. Pesticide levels were also slightly elevated. Sediments at station 1391, the second station located in the Outer Harbour, were comprised primarily of sand (94%) with a low silt (4%) and very low organic content. Contaminant levels were very low and well within M.O.E. guidelines. Station 2282, the third station in the Outer Harbour, was located close to station 1391 in a predominantly sandy area (61%). Silt content was low in this area and organic content, as a result, was only moderate. Most of the contaminants were within M.O.E. guidelines, or exceeded them only slightly.

Located in a bay or cell of the Eastern Headland, station 2108 was situated in a sand-silt substrate (49%-40%) of relatively low organic content. While most contaminant levels were low, high values were noted for PCBs and solvent extractables (Table 3.1.6).

Located near the base of the Eastern Headland, station 2238 was in a predominantly sandy area (96%) with very little silt or organic matter and low in contaminants.

Station 2034, located in Ashbridges Bay, yielded the highest sediment organic content of any of the stations outside the harbour (TOC = 41 mg/g; LOI = 8.5%). Contaminant levels (Table 3.1.6) were also very high and in some cases exceeded M.O.E. guidelines by nearly ten times (e.g., hydrocarbons and Cu) or more (PCBs were 18 times higher than the guidelines). Pesticides were the highest of any of the stations in the Toronto waterfront (especially A-chlordane (104 ng/g), B-chlordane (100 ng/g), dieldrin (68 ng/g), DMDT methoxyclor (208 ng/g), and heptachlor epoxide (40 ng/g)). In general, all parameters were considerably elevated.

Station 2227, located near the mouth of the Outer Harbour was very low in organic content (grain size data were unavailable), indicating silts were low and that sand comprised most of the substrate. Contaminant levels were also very low and well within M.O.E. guidelines. Station 2223 was located in a more open-water area and consisted of a predominantly sand substrate, moderately low in organic content (Table 3.1.6). Contaminant levels were moderately low, the exception being PCBs which were 8 times higher than the M.O.E. guidelines.

Stations 2207 and 2200, located offshore along the eastern waterfront, were both in areas of sandy substrate. Station 2207, the only station for which sediment analysis data were available, consisted of 97% sand and was very low in organic matter.

Benthic Invertebrates

At all three of the stations in the Outer Harbour, the fine sediment feeding infauna dominated the benthic populations. At station 1389 this group, comprised of the oligochaetes, Pisidium casertanum and Chironomus

plumosus, accounted for 99% of both faunal density (Table 3.1.8) and biomass (Table 3.1.7). The predacious chironomid Cryptochironomus and the epibenthic grazers Pontoporeia hoyi and Gammarus fasciatus made up the other groups present, but together accounted for only 1% of the fauna. The majority of the benthic fauna was oligochaetes (90%), though the community present was moderately diverse and consisted of species not commonly associated with extremes of organic enrichment, such as Spirosperma ferox and Potamothrix moldaviensis.

Despite the mainly sandy substrate and the low organic content, sediment fine particle feeders formed the major part of the fauna (85%) at station 1391, with epibenthic grazers (Endochironomus and Gammarus fasciatus) the only other group present. Much of the sediment fine particle feeders consisted of species associated with eutrophic conditions, such as Chironomus plumosus and the oligochaetes Tubifex tubifex and Limnodrilus. Total density of organisms and total biomass were the highest of any of the stations outside Toronto Harbour itself (Table 3.1.7). All of these factors, though especially the large population of G. fasciatus, indicated that while eutrophic conditions existed in this area, it was not severely polluted.

While sand still made up the major fraction of the sediments at station 2282, the benthic community was predominantly oligochaetes (83%, Table 3.1.7). Organic content was higher than at station 1391 and the percentage of sediment fine particle feeders was also higher, making up over 99% of the fauna. Despite the high density of oligochaetes, chironomids, regardless of their lower numbers, formed most of the biomass. The presence of Chironomus plumosus, a large-bodied species, was the main cause of this disparity. A small population of Gammarus fasciatus comprised the epibenthic grazer community, though this was represented by only a few individuals (Table 3.1.8). As at station 1391, the fauna indicated that eutrophic, and somewhat polluted, conditions existed in this part of the Outer Harbour.

Oligochaetes also dominated the benthic fauna at station 2108, comprising 80% of the fauna, and sediment fine particle feeders as a whole constituted 98% of the total fauna. A small group of predators (Cryptochironomus), and epibenthic grazers (P. hoyi and Asellus), comprised the remaining 2%. Overall, the density of organisms was lower than at the preceding stations, despite similar levels of organic matter. The oligochaete fauna (Table 3.1.8) was typical of near-shore (littoral) areas and was not dominated by the pollution tolerant forms typical of some areas in the Outer Harbour and Toronto Harbour.

Pesticide levels were also higher at this station and the increased levels of chlordanes, dieldrin and methoxyclor that occurred at this station (and at station 1389) may be at least partly responsible for some of the reduction in density, since the higher organic levels should logically have supported larger populations of both oligochaetes and chironomids, the two groups most reduced. However, conclusions based on changes in density in natural (field) situations are somewhat tenuous, since a number of other, wholly unrelated, factors may be influencing the

density in these areas.

Situated in a sandy area at the base of the eastern headland, station 2238 was low in both organic matter and contaminants. The benthic fauna was correspondingly reduced, and while comprised exclusively of sediment fine particle feeders, was low in both density and diversity. Present were only those organisms commonly associated with organic enrichment and low oxygen content, such as Tubifex tubifex and Limnodrilus hoffmeisteri. The reduced density of organisms is consistent with a sandy habitat, which in addition to providing little organic matter for food, can also be a suffocating environment (Hynes 1970). Presumably, currents created by the Eastern Headland were responsible for the mainly sand substrate and these erosional forces had likely resulted in little deposition of surficial coarse organic matter, since, as denoted by the fauna, only fine organic particles in the sand matrix appeared to be present.

Station 2034 was located in Ashbridges Bay, which was the most contaminated area along the Toronto Waterfront. Despite the increased contaminant levels, a sizeable oligochaete community was found to exist (ca. 9,000/m2, Table 3.1.7), though it was represented by the most pollution tolerant species. Density, however, was relatively low, despite the higher organic content. Since elevated organic levels commonly result in major increases in oligochaete density, which were lacking at this station, presumably other factors were serving to limit density of the fauna. Both a high rate of sedimentation and/or resuspension of fine material, or significantly elevated levels of contaminants could result in this type of effect. Evidence indicates the latter may be the cause at this station. Levels of all contaminants were high, with most reaching their highest levels outside of the harbour. Pesticide levels were similarly elevated. In addition, this area showed signs of relatively severe organic contamination based on the benthic fauna. Oligochaetes represented the only feeding group present, the sediment fine particle feeders, and were the exclusive representatives of this group.

Stations 2223 and 2227 were located on the lake-ward side of the Toronto Islands in apparently deeper water than any of the preceding stations. The main evidence for this was the appearance of a deep water, more mesotrophic community. Oligochaetes, the major component of the fauna at the nearshore stations, comprised a maximum of 44%.

Sediment fine particle feeders comprised 81% of the fauna at station 2227, of which Pisidium comprised the largest fraction. Much of the fauna was typical of other areas inside and outside the harbour, and consisted of such common species as Chironomus, Pisidium, and the oligochaetes Tubifex tubifex and Limnodrilus hoffmeisteri. While all of these are common in eutrophic areas, the appearance of such deep water oligotrophic species as Monodiamesa depectinata, Potthastia longimana, Pontoporeia hoyi, and Stylodrilus heringianus was significant.

A markedly different benthic fauna was evident at station 2223, though sediment fine particle feeders still formed the largest segment (89%) of the fauna. The presence of Stylodrilus heringianus, a common component of

the oligotrophic profundal regions of Lake Ontario (Kinney 1972) was indicative of the earlier mentioned shift to a mesotrophic fauna. (The mesotrophic classification has been determined on the basis of a mix of common eutrophic species such as Chironomus and the oligotrophic species, such as S. heringianus).

Station 2207, situated close to station 2238, was likely in an erosional environment as well. The fauna here contained elements of the shallow-water eutrophic fauna found elsewhere along the Eastern Headland, but in severely reduced numbers.

An even more extreme situation occurred at station 2200, where the few organisms found were likely deposited by the current, since no suitable sediment cover appeared to exist.

Three broad regions were delineated by stations outside the Toronto Harbour. The first was an area of organic deposition which occurred in the protected bays and shallows along the Outer Harbour and Eastern Headland (stations 1389, 1391, 2282, 2108, and 2034). These areas were characterized by accumulations of organic matter, as well as various contaminants. Most of these areas were not seriously contaminated, with the exception of Ashbridges Bay, where contaminant levels appeared to play a role in limiting the faunal density. The other depositional regions appeared to be suffering only from varying degrees of organic enrichment.

The second region (stations 2238, 2200, and 2207) was one of erosional environments, located offshore of the Eastern Waterfront and Eastern Headland, and were characterized by sandy substrates supporting low densities of organisms. Contaminant and organic matter levels were low, and the major factors effecting the benthos appeared to be current and hence substrate type.

The third region was represented by the deeper, offshore areas. Also low in organic content, the fauna at these stations (2223 and 2227) had a more mesotrophic character, containing organisms commonly found in the profundal regions of Lake Ontario. Depth and substrate appeared to be the major determining factors while contaminant levels were generally low with no apparent effect on the benthic community.

3.1.3. HUMBER BAY

Water Quality

Water quality parameters in Humber Bay were similar to those recorded in Toronto Harbour and along the Eastern Waterfront. The bay can be characterized as hard water, of high pH, and low in organic content. Waters were, for the most part, clear with only a small suspended particle load (Table 3.1.9).

Sediment Quality

Sediments in Humber Bay varied from sand, low in organic content, to silty areas high in organic matter. In broad terms the nearshore areas were primarily sand, while substrates in deeper areas were mainly silt (Table 3.1.10). Located in a bay near the sewage treatment plant, sediments at station 2113 were a mix of sand and silt (51% : 31%) moderately high in organic matter. Contaminant levels were also moderately high and most exceeded M.O.E. guidelines.

Sediments at station 2332 were primarily silt and were moderately high in organic content. Located off the headland in a depositional area, this station appeared to receive inputs of suspended materials as backwash from the Humber River, erosion from the headland, or both. Contaminant levels were all high, particularly some of the metals (Cu, Cr, and Zn) and solvent extractables (Table 3.1.10). Many of these were 4 to 5 times as high as the average for the other stations in the bay (excluding station 2335).

Located in the wave-zone area near Sunnyside Beach, sediments at station 2333 were almost entirely sand (95%) with a very low silt content, and with a correspondingly low level of contaminants.

Station 2335 was located in the center of the bay, off the mouth of the Humber River. It was situated approximately 1 km east of the mouth of Mimico Creek, and likely received outwash from both the Humber River and Mimico Creek, as well as washdown from the headland. Sediments were mainly silts (69%), with a high clay content (24%) and rich in organic matter (Table 3.1.10). Sediment contaminant levels were the highest of any of the stations in Humber Bay for almost all the parameters measured and all exceeded M.O.E. guidelines by significant amounts (many of the metals by 10 to 20 times e.g. Cu, Cr and Zn). Pesticides, though present, were at only moderate levels with dieldrin and endosulfan 1 the highest (33 and 40 ng/g respectively). The high levels of contaminants at both this station and station 2332 indicated that the most likely source of these was from the Humber River. The low levels around the headland (station 2113) indicated that only a minor amount was contributed by this source.

Station 2339, located near shore just east of the eastern end of Sunnyside Beach, appeared to be in an erosional area similar to station 2333. Though sediment grain size data were not available, it is inferred from the low organic content of the sediments that sand and gravel formed most of the substrate (Table 3.1.10). As has been typical for these types of substrates, contaminant levels were low and reflected the low sorptive capacity of sand.

The remaining four stations were located in deeper water in Lake Ontario. Sediments at station 2352 were comprised of a sand-silt mixture (38%-49%) relatively low in organic content. Contaminant levels were similarly low (Table 3.1.10). Station 2355 contained somewhat more silt (65%) than station 2352, and had a higher level of contaminants as well (Table 3.1.10). At both, however, the contaminant levels were below M.O.E. guidelines for most parameters (a notable exception was PCB levels at station 2355).

Located off the southwestern end of the Toronto Islands, station 2362 appeared to be in a depositional area similar to station 2355. Silts comprised 66% of the sediment at station 2363 and both organic content and contaminant levels were moderate (Table 3.1.10).

Station 2367 was located in an area of sandy sediments (71%) at the southwestern end of Humber Bay. Organic content was low as were levels of contaminants.

Benthic Invertebrates

Physical features of the sediments varied widely within Humber Bay, ranging from soft sediment in depositional areas to sand in the wave-zone areas. These features also influenced the benthic communities and, in large measure, determined the type of community that existed in each area.

Located in a bay near the sewage treatment plant (Fig. 3.1), station 2113 yielded a fauna typical of eutrophic and organically enriched areas. Sediments were a mix of sand and silt (51% : 31%). The benthic fauna consisted mainly of oligochaetes (Table 3.1.11) and though these comprised 97% of the fauna, they did constitute a fairly diverse community (Table 3.1.12). Sediment fine particle feeders as a whole comprised 99% of the fauna with the only other group present being a small population of Gammarus fasciatus, an epibenthic grazer. This bay appeared to act as a settling basin, and faunistically was typical of shallow, organically polluted areas.

Station 2332 was located off the eastern end of the headland near both the Humber River inflow and the sewage treatment plant (Fig. 3.1). Sediments were primarily silt, moderately high in organic content, and high in contaminants. The benthic fauna was very low in density in comparison to other areas of the bay, though the reasons for this are somewhat unclear. While contaminant levels were high, in many cases these were higher still at station 2335 (Table 3.1.10), which yielded a sizeable benthic community (Table 3.1.12). The lower clay content at station 2332 may have meant that more of the contaminants were available in other fractions of the sediments, but this remains unproven. Physical conditions of the substrate indicate that a sizeable benthic population could have been supported in this area. The large organic fraction, however, actually supported a small population of exclusively fine sediment feeders.

Station 2333, located east of the Humber River just off the breakwater at Sunnyside Beach, was situated in an erosional area. Sediments were almost entirely sand, though this rather sterile environment did manage to support a moderately large benthic community, dominated by sediment fine particle feeders (mainly oligochaetes). Species composition was restricted mainly to Q. multisetosus, an inhabitant of sandy areas, rather than the Tubifex tubifex - Limnodrilus community common in the siltier, organic sediments. Predators (Cryptochironomus) and grazers (P. hoyi) made up the very small remaining fraction of the fauna (0.02% and 0.006% respectively). Evidently, substrate and lack of organic matter were the major determining

factors at this station.

Station 2335 was located in the center of the bay, off the mouth of the Humber River, and approximately 1 km east of the mouth of Mimico Creek. Both of these likely contributed sediments to this part of the bay. Sediments were mainly silts (69%) with a high clay content (24%) and rich in organic matter (Table 3.1.10). Sediment contaminant levels were the highest of any of the stations in Humber Bay for almost all the parameters measured (all 8 parameters for which guidelines are available were exceeded, usually by significant amounts). A sizeable benthic community, comprised mainly of oligochaetes (over 99% of the fauna) occurred here, despite the elevated contaminant levels. All of the organisms present (100%) were sediment fine particle feeders (Table 3.1.12) and the fauna was comprised mainly of the Tubifex tubifex - Limnodrilus spp. community common to organically polluted areas.

The high density of organisms that existed at this station in spite of the high contaminant levels may be due to many of these being in a form unavailable to the organisms (see section 3.1.1, station 1360). Many contaminants, especially metals, are adsorbed onto the fine-grained particles (Poulton et al 1980), and the high clay content of these sediments may therefore have had a moderating effect. It is possible that the clay fraction of the sediment, normally a hostile environment for benthic organisms, was acting as a sink for some of the metals and other contaminants noted in Table 3.1.10.

Station 2339, located near shore just east of the eastern end of Sunnyside Beach, appeared to be in an erosional area similar to station 2333. Though sediment grain size data were not available, it is inferred from the low organic content of the sediments that sand and gravel formed most of the substrate (Table 3.1.10). The benthic community was also rather reduced in density and was comprised mainly of oligochaetes (72%) of which the most common species was L. hoffmeisteri. The sediment fine particle feeders comprised 82% of the fauna while predators (Cryptochironomus) and grazers (P. hoyi) made up the remaining 14%. The reduced organic content and the generally erosional environment appear to have limited the density of the fauna.

The remaining stations were located in deeper water further out in the bay (Fig. 3.1) and were generally characterized by a more mesotrophic fauna.

Sediments at station 2352 were comprised of a sand-silt mixture (38%-49%), and the benthic community consisted of two major components; the fine sediment detritivores such as the chironomids, the oligochaetes, and the clam Pisidium casertanum; and the epibenthic grazer community represented solely by Pontoporeia hoyi, which made up 57% of the density and 61% of the biomass (Table 3.1.11). The shift to a community dominated by P. hoyi among the amphipods and Stylodrilus heringianus among the oligochaetes is characteristic of the deeper, oligotrophic regions of Lake Ontario (Kinney 1972). These two species make up a large part of the benthic community in the profundal regions and it is apparent that the relatively high level of

organic matter has permitted a large population of each to develop at this station.

Though silt content was slightly higher at station 2355, the benthic fauna was very similar to that at station 2355 (Table 3.1.12) and differed chiefly in the increased density of the organisms. The fauna was again dominated by Pontoporeia hoyi (54%) and Stylodrilus heringianus (25%). As at station 2352, sediment surface grazers (P. hoyi) formed the major ecological group, with the sediment fine particle feeders comprising the remaining 45% (mainly S. heringianus).

Located off the southwestern end of the Toronto Islands, station 2362 appeared to be in a depositional area (silt content was 66%) similar to station 2355. The density of organisms was high, and was likely a result of the higher organic content of the sediments. As a result, most of the density was concentrated in the fine sediment feeders (90%) of which the major group was the oligochaetes (80% of the total fauna). Predators (Procladius) and epibenthic grazers made up the remainder (0.8% and 9.3% respectively). Absent was the deep-water oligochaete S. heringianus, and the P. hoyi population was reduced in density, indicating shallower conditions, a higher level of organic matter, or both.

Station 2367 was located in an area of sandy sediments (71%) at the southwestern end of Humber Bay. The lower density of organisms reflected the lower organic content of the sediments though the composition of the fauna had not changed. Sediment fine particle feeders still dominated the fauna and only their density was reduced.

In summary, the stations located in Humber Bay defined four broad zones. The first was a shallow-water zone characterized by the deposition of fine sediments and high organic content. The benthic community was typical of eutrophic littoral areas, comprised mainly of fine particle feeders, the chironomids and oligochaetes. Where contaminant levels were low, the fauna appeared quite diverse (station 2113) and density was high. Where contaminant levels were high, the fauna appeared to be reduced (station 2332). This zone was apparently restricted to the protected bays and shoreline areas.

The second zone was an erosional area along the open shoreline of the bay, which as a result of wave or current action appeared to retain little organic matter. As a consequence, these areas (stations 2333 and 2339) were low in sediment organic content, and density and biomass of the benthos was lower. The sandy substrate, low in organic matter, bore little evidence of contaminants.

The eutrophic third zone lay further offshore in an area of deeper water that appeared to receive much of the fine sediments that were carried as outwash from Humber River and Mimico Creek, and as washdown from shallower, shoreline areas. This area of silty sediments, high in organic content (station 2335), was characterized by elevated contaminant levels and high densities of typically eutrophic species (oligochaetes).

The last zone was the deeper, mesotrophic area furthest out into Lake Ontario. These areas (stations 2352, 2355, 2363, and 2367) were characterized by faunal elements typical of the deep, oligotrophic areas of Lake Ontario, though they did contain some characteristically eutrophic elements as well. Contaminant levels were low and appeared to have no effect on the fauna at these locations.

3.1.4. SUMMARY

1) Areas along the Toronto Waterfront, inside Toronto Harbour (stations 1346, 1360, 1379), at Ashbridge Bay (station 2034), and Mimico Creek (station 2113) appeared to be organically polluted. The benthic communities were reduced in diversity and consisted primarily of oligochaetes and chironomids. Species present were typical of organically polluted areas.

2) The areas noted in (1) above were also the most chemically contaminated areas, though the benthic community, already a stressed fauna, bore no clear evidence of effects by these chemical pollutants except for a general reduction in density where contaminant levels were highest. A general reduction in faunal density, as compared to earlier studies, was evident throughout. Though such a reduction is consistent with sub-acute effects of contaminants, it is more likely to have occurred primarily as a result of lower organic content in the sediments or seasonal changes in benthic production.

3) Areas further offshore, such as station 1368, stations 1391, 1389, 2282, 2108, and stations 2331 bore evidence of organic enrichment, though the fauna appeared less severely affected than at the stations noted in (1) above. Contaminant levels were generally lower as well.

4) Sandy, erosional areas had their own characteristic faunas and were found at stations 2333, 2339, 2200, 2238, and 2207. Sediments in these areas were characterized by very low organic levels.

5) A more mesotrophic area appeared offshore, in deeper waters, as defined by the benthic communities at stations 2367, 2352, 2355, 2223, and 2227. All had low organic and contaminant levels and contained elements of the benthos more typical of the oligotrophic profundal regions of Lake Ontario.

6) Finally, a littoral, eutrophic though apparently not polluted zone existed near the Toronto Islands, inside the harbour at stations 1352, 1359, 1367, and 1373. All were characterized by a large diversity and density of littoral organisms, many commonly associated with coarse detritus and macrophytes. Though organic content was variable, contaminant levels were generally low.

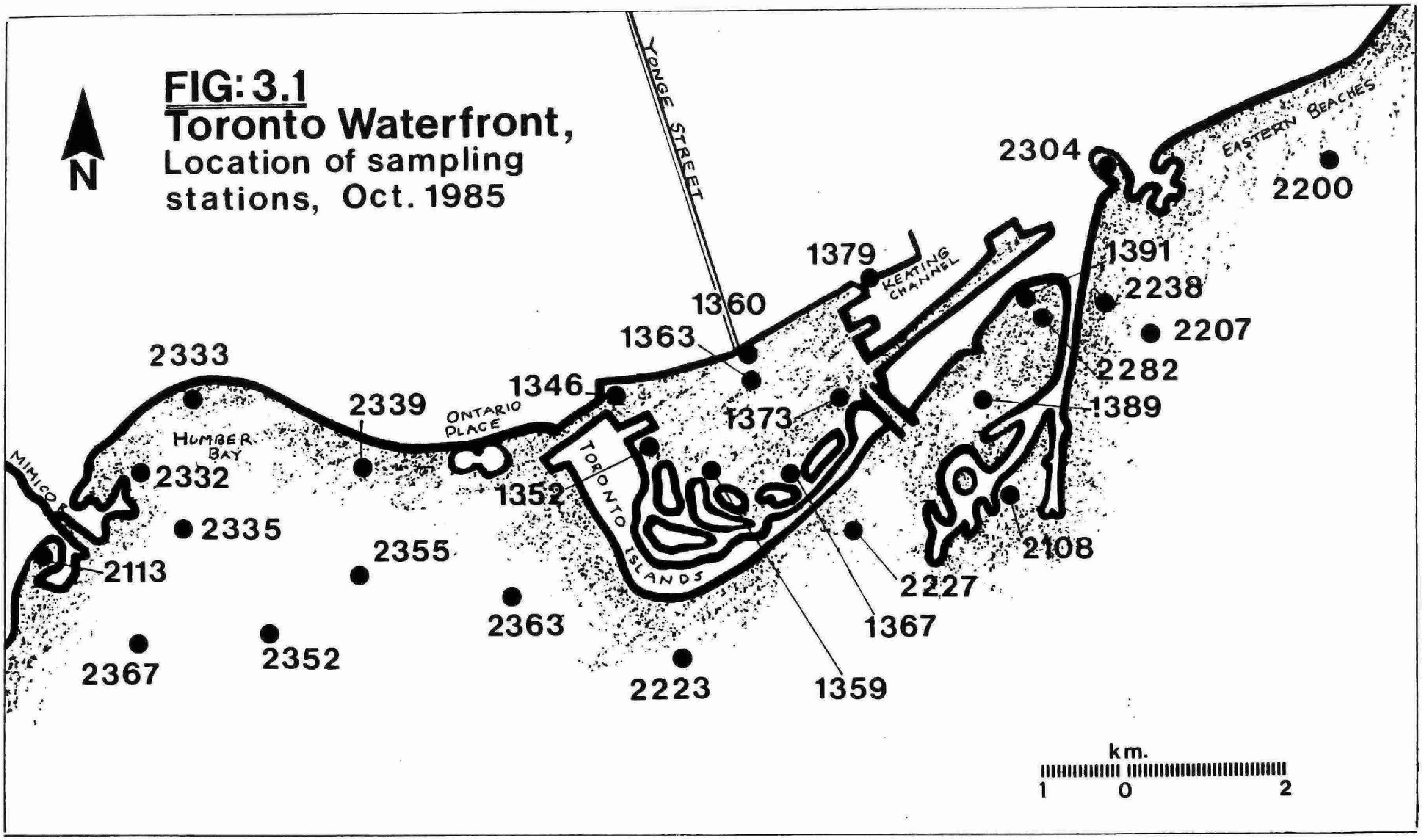
FIG: 3.1
Toronto Waterfront,
Location of sampling
stations, Oct. 1985
N
YONGE STREET
EASTERN BEACHES
KEATING CHANNEL
ONTARIO PLACE
HUMBER BAY
MIMICO
TORONTO ISLANDS
2304
2200
1379
1391
2238
2207
1360
1363
2282
2333
1346
1389
2339
1373
2332
1352
2335
2355
2113
2108
2227
2363
1367
2367
2352
2223
1359
km.
1
0
2

TABLE 3.1.1. WATER QUALITY DATA - TORONTO HARBOUR. (TAKEN 1 M OFF BOTTOM).

Station Number	pH	Hardness (mg/l)	Chemical Oxygen Demand (COD) (mg/l)	Dissolved Organic Carbon (DOC) (mg/l)	Total Kjeldahl Nitrogen (TKN) (mg/l)	Turbidity	Suspended Particulate (mg/l)	Sodium (Na) (mg/l)	Chloride (Cl) (mg/l)
1346	8.00	139.0	7.5	2.1	0.24	3.10	4.54	16.00	30.75
1360	8.28	129.5	6.5	2.2	0.40	1.64	6.67	18.60	35.45
1379	8.29	248.5	17.2	3.5	1.20	11.50	36.56	60.60	113.00
1363	7.91	154.0	28.2	2.2	0.50	> 200.00	325.00	17.10	33.45
1352	8.03	141.0	4.7 < T	2.2	0.27	5.20	4.81	15.20	29.60
1359	8.22	140.0	7.7	2.2	0.31	2.30	3.81	16.60	30.35
1373	8.05	143.0	3.6 < T	2.0	0.25	1.17	3.79	14.30	29.15
1367	8.03	138.0	4.4 < T	2.1	6.67	2.60	6.40	13.40	27.25

TABLE 3.1.2. SEDIMENT DATA - TORONTO HARBOUR.

Station Number	Grain Size (%) Gravel/Sand/Silt/Clay	Total Organic Carbon (TOC) (mg/g)	Loss on Ignition (LOI) (%)	Total Phosphorus (TP) (mg/g)	Total Kjeldahl Nitrogen (TKN) (mg/g)	Solvent Extractables (ug/g)
1346	2/46/38/7	50.0	6.70	1.54	1.80	8,500.0
1360	0/20/57/22	51.0	7.60	1.82	1.40	12,429.0
1379	0/96/4/1	26.0	0.44	0.53	0.10	439.0
1363	0/3/64/32	< 5.0	5.00	1.47	1.60	4,555.0
1352	5/85/8/2	8.0	0.70	0.40	0.30	243.0
1359	0/96/3/1	< 5.0	0.46	0.39	0.10	94.0
1373	1/93/4/1	< 5.0	0.76	0.37	0.20	394.0
1367	3/91/4/1	< 5.0	0.86	0.40	0.30	255.0

Station Number	Cu (ug/g)	Cr (ug/g)	Hg (ug/g)	Fe (ug/g)	As (ug/g)	Zn (ug/g)	Al (ug/g)	Total PCB's (ug/kg)
1346	140.0	85.0	2.60	16,000.0	6.56	420.0	9,500.0	1,590
1360	320.0	170.0	1.40	23,000.0	10.52	650.0	16,000.0	< 20
1379	15.0	15.0	0.03	7,900.0	0.73	97.0	2,300.0	20
1363	100.0	110.0	0.33	27,000.0	9.67	320.0	20,000.0	490
1352	11.0	12.0	< 0.01	5,800.0	1.43	21.0	2,700.0	< 20
1359	5.7	7.7	< 0.01	2,900.0	0.94	10.0	1,600.0	< 20
1373	9.6	9.9	0.02	4,200.0	1.15	28.0	2,400.0	< 20
1367	11.0	11.0	< 0.01	7,100.0	1.29	30.0	2,600.0	< 20

TABLE 3.1.3. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA - TORONTO HARBOUR.

All values are expressed as #'s per square meter.

	Station #1346		Station #1360		Station #1379	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Trichoptera						
O. Coleoptera						
O. Diptera						
F. Chironomidae	31	0.0028	10			
O. Lepidoptera						
Class Arachnida						
O. Acarina						
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda						
O. Isopoda						
MOLLUSCA						
Class Gastropoda	10	0.078	123	3.625	24	0.0478
Class Pelecypoda			123	0.4843	3	
ANNELIDA						
Class Hirudinea						
Class Oligochaeta	5,791	3.4832	31,375	23.9684	20,365	17.2952
TOTAL # ORGANISMS	5,832		31,631		20,392	
TOTAL BIOMASS		3.5640		28.078		17.343
CORRECTED BIOMASS (+10%)		3.9204		30.8858		19.0773

TABLE 3.1.3. (Continued)

All values are expressed as #'s per square meter.

	Station #1363		Station #1352		Station #1359	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Trichoptera						
O. Coleoptera						
O. Diptera						
F. Chironomidae	14	0.0066	375	0.1817	825	0.2208
O. Lepidoptera						
Class Arachnida						
O. Acarina			46	0.1476		
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda			735	0.1045	812	0.4617
O. Isopoda	4	0.0065	349	0.2244		
MOLLUSCA						
Class Gastropoda	8	0.2492	581	7.9701	1,593	8.7784
Class Pelecypoda	1,524	3.6757	198	2.2498	512	2.1518
ANNELIDA						
Class Hirudinea			25	0.0408	46	0.2203
Class Oligochaeta	3,595	2.9770	917	0.1752	1,675	0.5071
TOTAL # ORGANISMS	5,145		3,221		5,463	
TOTAL BIOMASS		6.9150		11.0941		12.3401
CORRECTED BIOMASS (+10%)		7.6065		12.2035		13.5741

TABLE 3.1.3. (Continued)

All values are expressed as #'s per square meter.

Station #1373		Station #1367	
Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
		5	
		3	0.0042
989	0.7682	586	0.6168
		5	
13	0.0073		
903	0.7822	3,594	2.8750
12	0.0032	23	0.0227
596	3.7548	318	1.6880
343	1.4655	541	1.7514
37	0.0596	8	0.1562
1,322	0.4497	249	0.1243
4,215		5,332	
	7.2905		7.2386
	8.0196		7.9625

TABLE 3.1.4. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - TORONTO HARBOUR.

SPECIES	STATION NUMBER (#/m²)							
	1346	1360	1379	1363	1352	1359	1373	1367
TRICHOPTERA								
Hydroptilidae: Agraylea sp.								15
LEPIDOPTERA								
Munroessa sp.								15
DIPTERA								
Chironomidae:								
Cryptochironomus sp.		31			433	379	440	207
Chironomus plumosus group				11			38	8
Dicrotendipes sp.								84
Endochironomus dispar group					88	425	417	674
Glyptotendipes (Glyptotendipes)					31	12		
Cladotanytarsus sp.						12		
Procladius sp.	61	31		8				
AMPHIPODA								
Gammaridae:								
Gammarus fasciatus					663	1,137	724	
G. lacustris								4,374
ISOPODA								
Asellidae: Asellus sp.				4	100		23	31
PELECYPODA								
Sphaeriidae:								
Sphaerium striatinum				8	15	11		
Pisidium casertanum		92	8	1,011	73	1,505	417	551
Musculium transversum								8
GASTROPODA								
Valvatidae:								
Valvata sincera			12		245	310	234	15
V. tricarinata					42	149	234	138
Physidae:								
Physella gyrina sayi						23		46
Lymnaeidae:								
Stagnicola catascopium						11		
Pseudosuccinea columella								8
Planorbidae:								
Helisoma sp.							23	
Hydrobiidae:								
Amnicola limosa		153		8	42	11		77
Bithynia tentaculata							50	
HIRUDINEA								
Helobdella stagnalis					15			
Mooreobdella sp.						34	38	6
OLIGOCHAETA								
Naididae: sp. indet.		858						
Enchytraeidae: sp. indet.						80	38	
Tubificidae:								
Tubifex tubifex		4,167	552	582				
Quistadrilus multisetosus		1,655		429				
Potamothrix moldaviensis			2,267			230	111	23
Limnodrilus hoffmeisteri	214	1,655	3,953		142	540	406	
L. claparedeianus			552	291				
L. udekemianus			1,685					
Immatures with capilliform setae	674	5,025		582		80		
Immatures without capilliform setae	4,872	10,050	10,724	1,593	559	919	551	161
Total Number of Organisms	5,821	22,859	19,753	4,527	2,448	5,868	2,744	6,413
Species Diversity (H')	0.82	2.25	1.90	2.43	2.89	3.10	3.31	1.32
Species Richness (S.R.)	0.41	1.03	0.82	1.41	1.86	2.32	2.03	2.29
Evenness (J')	0.41	0.68	0.63	0.70	0.78	0.74	0.84	0.44

TABLE 3.1.5. WATER QUALITY DATA - TORONTO OUTER HARBOUR AND EASTERN HEADLAND (TAKEN 1 M OFF BOTTOM).

Station Number	pH	Hardness (mg/l)	Chemical Oxygen Demand (COD) (mg/l)	Dissolved Organic Carbon (DOC) (mg/l)	Total Kjeldahl Nitrogen (TKN) (mg/l)	Turbidity	Suspended Particulate (mg/l)	Sodium (Na) (mg/l)	Chloride (Cl) (mg/l)
1389	7.98	134.0	10.3	2.0	0.29	25.00	35.30	13.00	25.65
1391	8.12	124.5	8.2	2.2	0.26	0.97	1.98	12.90	26.05
2282	8.11	132.0	5.7	2.2	0.26	1.87	1.64	13.30	25.60
2108	8.20	129.0	7.2	2.1	0.26	3.50	10.23	12.50	24.95
2238	8.22	133.0	5.7	2.0	0.30	1.81	4.58	12.30	24.40
2034	7.94	153.5	17.5	3.4	3.30	6.00	31.84	28.70	55.30
2223	8.06	126.5	4.1	2.0	0.25	1.85	5.09	12.80	24.90
2227	8.34	136.0	5.7	1.9	0.27	0.72	2.16	12.90	25.65
2207	8.11	126.0	6.5	2.0	0.31	2.20	14.73	11.90	24.40
2200	8.30	126.0	7.2	2.1	0.25	0.85	0.16	11.90	24.40

TABLE 3.1.6. SEDIMENT DATA - TORONTO OUTER HARBOUR AND EASTERN HEADLAND

Station Number	Grain Size (%) Gravel/Sand/Silt/Clay	Total Organic Carbon (TOC) (mg/g)	Loss on Ignition (LOI) (%)	Total Phosphorus (TP) (mg/g)	Total Kjeldahl Nitrogen (TKN) (mg/g)	Solvent Extractables (ug/g)
1389	0/14/59/24	30.0	4.40	0.83	0.80	3,294.0
1391	0/94/4/1	< 5.0	0.69	0.14	0.20	392.0
2282	0/62/26/6	15.0	2.00	0.81	0.50	966.0
2108	0/49/40/6	14.0	2.10	0.73	0.30	2,627.0
2238	0/97/2/1	< 5.0	0.28	0.80	0.10	143.0
2034	0/42/43/9	41.0	8.50	2.41	1.30	14,456.0
2223	0/78/16/3	8.9	1.10	0.67	0.50	3,160.0
2227	-	< 5.0	0.28	0.84	0.10	192.0
2207	1/97/1/0	< 5.0	0.39	0.56	0.10	77.0
2200	-	-	-	-	-	-

Station Number	Cu (ug/g)	Cr (ug/g)	Hg (ug/g)	Fe (ug/g)	As (ug/g)	Zn (ug/g)	Al (ug/g)	Total PCB's (ug/kg)
1389	80.0	70.0	0.33	28,000.0	12.12	230.0	19,000.0	465
1391	19.0	16.0	0.02	14,000.0	2.43	39.0	2,800.0	< 20
2282	34.0	37.0	0.09	17,000.0	4.03	90.0	8,900.0	70
2108	28.0	20.0	0.12	13,000.0	3.22	74.0	8,100.0	105
2238	7.7	9.2	0.02	5,700.0	5.10	12.0	2,400.0	< 20
2034	220.0	130.0	0.80	20,000.0	5.09	700.0	9,800.0	900
2223	32.0	62.0	0.16	9,500.0	2.14	79.0	5,800.0	415
2227	7.3	10.0	< 0.01	6,700.0	1.43	15.0	2,200.0	< 20
2207	3.9	5.5	< 0.01	5,900.0	1.22	10.0	1,900.0	< 20
2200	-	-	-	-	-	-	-	-

TABLE 3.1.7. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA - TORONTO OUTER HARBOUR AND EASTERN HEADLAND.

All values are expressed as #'s per square meter.

	Station #1389		Station #1391		Station #2282	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Diptera						
F. Chironomidae	281	1.3955	3,314	1.3454	1,329	5.9767
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	9	0.0133	1,900	1.5963	9	0.0113
O. Isopoda	1		20	0.0625	3	0.0036
MOLLUSCA						
Class Gastropoda	1	0.0646	414	6.7739	3	0.0855
Class Pelecypoda	81	0.2521	276	0.7177	240	0.3989
PLATYHELMINTHES						
Class Turbellaria			138	0.1909		
ANNELIDA						
Class Oligochaeta	3,189	4.8676	11,051	3.2669	7,619	1.0584
TOTAL # ORGANISMS	3,562		16,990		9,203	
TOTAL BIOMASS		6.5931		13.9535		7.5247
CORRECTED BIOMASS (+10%)		7.2524		15.3488		8.2772

TABLE 3.1.7. (Continued)

All values are expressed as #'s per square meter.

	Station #2108		Station #2238		Station #2034	
	Average # Organisms	**Biomass (gms)**	**Average # Organisms**	**Biomass (gms)**	**Average # Organisms**	**Biomass (gms)**
ARTHROPODA						
Class Insecta						
O. Diptera						
F. Chironomidae	146	0.2725	18	0.017		
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	28	0.0144				
O. Isopoda	13	0.0139				
MOLLUSCA						
Class Gastropoda	7	0.0205				
Class Pelecypoda	53	0.3039				
PLATYHELMINTHES						
Class Turbellaria						
ANNELIDA						
Class Oligochaeta	4,566	2.8251	1,771	0.4854	9,819	3.7104
TOTAL # ORGANISMS	4,813		1,789		9,819	
TOTAL BIOMASS		3.4503		0.5024		3.7104
CORRECTED BIOMASS (+10%)		3.7953		0.5526		4.0814

TABLE 3.1.7. (Continued)

All values are expressed as #'s per square meter.

Station #2223		Station #2227		Station #2207		Station #2200	
Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
114	0.0257	232	0.0601	8	0.0012	3	0.0001
148	0.2354	43	0.0122	33	0.0254		
1		1					
6	0.0012	9	0.0018				
481	0.5669	280	0.0621	10	0.0117		
885	0.6710	383	0.0493	186	0.0856	8	0.0003
1,635		948		237		11	
	1.5002		0.1855		0.1239		0.0004
	1.6502		0.2041		0.1363		0.0004

TABLE 3.1.8. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - TORONTO OUTER HARBOUR AND EASTERN HEADLAND.

SPECIES	STATION NUMBER (#/m²)									
	1389	1391	2282	2108	2238	2034	2223	2227	2207	2200
DIPTERA										
Chironomidae:										
Cryptochironomus sp.	8		134	4			42	169	8	4
Chironomus plumosus group	241	2,329	1,245	69	23		23	57	11	
Dicrotendipes sp.				27						
Endochironomus dispar group		414								
Tanytarsus sp.		92								
Monodiamesa depectinata							77	27		
Potthastia longimana							4	4		
Procladius sp.				23			19	4		
AMPHIPODA										
Haustoridae:										
Pontoporeia hoyi	4			38			130	12	23	
Gammaridae:										
Gammarus fasciatus	4	1,318	8					61		
ISOPODA										
Asellidae: Asellus sp.	4			19			4			
PELECYPODA										
Sphaeriidae:										
Sphaerium nitidum								8		
Pisidium casertanum	54	92		23				697	4	
P. compressum			8							
P. fallax			287				421			
P. henslowanum							103			
P. lilljeborgi									8	
P. variabile		31								
GASTROPODA										
Valvatidae:										
Valvata sincera							8			
Physidae:										
Physella gyrina sayi								4		
Lymnaeidae:										
Pseudosuccinea columella							4			
Planorbidae:										
Helisoma anceps				8						
Hydrobiidae:										
Amnicola limosa		199								
OLIGOCHAETA										
Lumbriculidae:										
Stylodrilus heringianus							230	12	19	
Tubificidae:										
Tubifex tubifex	521	322	582	291	77	410		12		
Spirosperma ferox	107									
Quistadrilus multisetosus	843			138		410				
Potamothrix vejdovskyi	429	322		138						
P. moldaviensis								61		
L. hoffmeisteri		322	306	444	383	2,451		169		
L. claparedeianus		980	1,808			816				
L. udekemianus									19	
Immatures with capilliform setae	1,379		2,083	2,482	153	410	27			4
Immatures without capilliform setae	735	6,894	3,003	291	839	4,454	402	103	142	4
Total Number of Organisms	4,329	13,315	9,464	3,970	1,475	8,951	1,505	1,400	234	12
Species Diversity (H')	2.60	2.29	2.51	2.03	1.62	1.94	2.80	2.49	1.99	2.00
Species Richness (S.R.)	1.56	1.35	1.15	1.87	0.67	0.64	2.35	2.37	1.70	2.16
Evenness (J')	0.72	0.64	0.75	0.53	0.70	0.75	0.71	0.64	0.66	1.00

TABLE 3.1.9. WATER QUALITY DATA - HUMBER BAY. (TAKEN 1 M OFF BOTTOM).

Station Number	pH	Hardness (mg/l)	Chemical Oxygen Demand (COD) (mg/l)	Dissolved Organic Carbon (DOC) (mg/l)	Total Kjeldahl Nitrogen (TKN) (mg/l)	Turbidity	Suspended Particulate (mg/l)	Sodium (Na) (mg/l)	Chloride (Cl) (mg/l)
2113	8.28	130.0	7.7	1.8	0.26	1.63	2.77	12.66	25.61
2332	8.27	-	14.7	1.8	0.73	1.27	15.46	14.62	27.67
2333	8.28	127.5	7.5	2.1	0.25	1.09	1.02	12.20	24.45
2335	8.29	128.0	7.2	1.8	0.29	1.06	11.63	12.86	25.51
2339	8.31	138.0	6.7	1.9	0.33	1.19	4.02	13.00	25.90
2352	8.35	124.5	7.9	2.1	0.25	1.42	6.19	12.10	25.15
2355	8.23	125.5	6.5	2.0	0.28	2.80	9.16	12.10	24.60
2363	8.23	126.5	7.0	2.0	0.30	1.56	4.25	12.90	24.50
2367	7.87	131.5	11.3	1.9	0.71	37.00	39.90	13.00	26.25

TABLE 3.1.10. SEDIMENT DATA - HUMBER BAY.

Station Number	Grain Size (%) Gravel/Sand/Silt/Clay	Total Organic Carbon (TOC) (mg/g)	Loss on Ignition (LOI) (%)	Total Phosphorus (TP) (mg/g)	Total Kjeldahl Nitrogen (TKN) (mg/g)	Solvent Extractables (ug/g)
2113	0/52/39/9	21.0	2.80	1.15	1.10	3,353.0
2332	0/15/69/14	58.0	12.00	8.35	7.60	10,873.0
2333	1/96/2/1	< 5.0	0.43	0.35	0.10	191.0
2335	0/5/69/25	59.0	12.00	9.23	6.70	12,658.0
2339	-	< 5.0	0.45	0.43	0.20	283.0
2352	0/38/49/9	7.4	1.90	0.63	0.40	420.0
2355	0/20/66/11	14.0	2.60	0.59	0.50	1,841.0
2363	0/15/67/14	17.0	3.40	0.92	0.90	1,758.0
2367	0/72/20/6	6.0	1.50	0.58	0.40	757.0

Station Number	Cu (ug/g)	Cr (ug/g)	Hg (ug/g)	Fe (ug/g)	As (ug/g)	Zn (ug/g)	Al (ug/g)	Total PCB's (ug/kg)
2113	88.0	53.0	0.11	18,000.0	4.26	210.0	9,500.0	85
2332	260.0	400.0	0.74	28,000.0	4.20	970.0	11,000.0	190
2333	8.0	5.5	< 0.01	3,900.0	0.94	21.0	1,800.0	< 20
2335	340.0	670.0	0.86	33,000.0	10.15	1,300.0	17,000.0	305
2339	16.0	20.0	0.02	9,800.0	1.36	44.0	3,100.0	< 20
2352	26.0	31.0	0.15	15,000.0	3.59	65.0	11,000.0	40
2355	42.0	55.0	0.22	17,000.0	4.94	110.0	11,000.0	190
2363	50.0	64.0	0.18	19,000.0	4.78	130.0	13,000.0	80
2367	24.0	30.0	0.13	11,000.0	3.59	71.0	6,000.0	25

TABLE 3.1.11. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA - HUMBER BAY.

All values are expressed as #'s per square meter.

	Station #2113		Station #2332		Station #2333	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Coleoptera	8	0.0196				
O. Diptera						
F. Chironomidae	157	0.2018	25	0.0814	24	0.0301
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	14	0.039			3	
O. Isopoda						
MOLLUSCA						
Class Gastropoda	27	0.1890	25	0.1768		
Class Pelecypoda	268	0.7552			6	0.0213
ANNELIDA						
Class Oligochaeta	14,374	7.8986	508	0.4736	4,448	0.4209
TOTAL # ORGANISMS	14,848		558		4,481	
TOTAL BIOMASS		9.0681		0.7318		0.4723
CORRECTED BIOMASS (+10%)		9.9749		0.8050		0.5195

TABLE 3.1.11. (Continued)

All values are expressed as #'s per square meter.

	Station #2335		Station #2339		Station #2352	
	Average # Organisms	**Biomass (gms)**	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Coleoptera						
O. Diptera						
F. Chironomidae	25	0.0768	64	0.0188	41	0.0236
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda			4	0.0012	3,958	1.6915
O. Isopoda						
MOLLUSCA						
Class Gastropoda	5		9	0.0448		
Class Pelecypoda	52	0.3239	34	0.056	322	0.6164
ANNELIDA						
Class Oligochaeta	3,937	2.3218	326	0.1068	1,879	0.454
TOTAL # Organisms	4,019		437		6,200	
TOTAL BIOMASS		2.7225		0.2276		2.7933
CORRECTED BIOMASS (+10%)		2.9948		0.2504		3.0726

TABLE 3.1.11. (Continued)

All values are expressed as #'s per square meter.

Station #2355		Station #2363		Station #2367	
Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
14	0.0013	15	0.0061	48	0.0069
4,364	7.4155	1,203	0.7830	268	0.1004
		87	0.1133		
443	0.7314	1,243	2.5454	574	1.6705
2,677	1.4142	8,283	10.7478	2,242	0.7429
7,498		10,831		3,132	
	9.5624		14.1956		2.5207
	10.5186		15.6152		2.7727

TABLE 3.1.12. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - HUMBER BAY.

SPECIES	STATION NUMBER (#/m²) 2113	2332	2333	2335	2339	2352	2355	2363	2367
DIPTERA									
Chironomidae:									
Cryptochironomus sp.			23		100				
Chironomus plumosus group	203	15							
Tanytarsus sp.						15	15		19
Brillia sp.						15			
Procladius sp.						31	15	23	27
AMPHIPODA									
Haustoridae:									
Pontoporeia hoyi			8		4	4,259	5,377	850	237
Gammaridae:									
Gammarus fasciatus	19								
ISOPODA									
Asellidae: Asellus sp.								31	
PELECYPODA									
Sphaeriidae:									
Sphaerium striatinum			4		11				
Pisidium casertanum	268		4	42	50	659	582	743	46
P. compressum								245	417
GASTROPODA									
Valvatidae: Valvata sincera	19	15			15				
OLIGOCHAETA									
Tubificidae:									
Tubifex tubifex	2,482	15	146	689	19		230		597
Quistadrilus multisetosus	368								
Potamothrix vejdovskyi					19				109
P. moldaviensis	368	8		180	19				
Limnodrilus hoffmeisteri	766	92		1394	176	107			268
L. claparedeianus	1501			525					
L. udekemianus				525					
Immatures with capilliform setae	1,990		195	180		781	674	3,401	268
Immatures without capilliform setae	7,936	61	873	1,214	176	107	551	4,167	931
Lumbriculidae:									
Stylodrilus heringianus					19	1,455	2,451		
Total Number of Organisms	15,830	206	1,253	4,749	593	7,429	9,895	9,460	3,009
Species Diversity (H')	2.28	2.05	1.34	2.55	2.67	1.82	1.87	1.84	2.75
Species Richness (S.R.)	1.20	1.25	1.04	0.98	1.97	1.06	0.89	0.77	1.35
Evenness (J')	0.66	0.79	0.48	0.85	0.77	0.57	0.62	0.65	0.83

3.2. OAKVILLE HARBOUR

Introduction

The lower reaches of Oakville Creek serve as a harbour for small pleasure craft, to which end two docking areas have been constructed on either side of the river. The creek also receives input from urban and rural areas. The former contributes runoff from urban areas, while the latter contributes runoff from agricultural areas. Both of these contribute sediment, organic and some chemical contaminants to the creek.

Water Quality

The lower reaches of Oakville Creek were characterized as predominantly hard water (Table 3.2.1) with a high pH and a moderately high organic load (COD and DOC, Table 3.2.1). The waters were fairly turbid in the upper reaches of the study area, with increasing turbidity towards the mouth of the creek. Suspended particle load followed a similar pattern, increasing downstream. The greatest increase in both turbidity and suspended particle load was at those stations near the mouth of the creek, where river flow was physically constricted. This high energy environment (stations 2842 and 2848, Fig. 3.2) apparently resuspends material and carries it into the lake. Salts were moderately high and values were consistent with levels recorded along the Toronto Waterfront.

Sediment Quality

Sediments at the majority of stations were predominantly silt and sand, with a consistently high clay fraction at all stations. Levels of contaminants varied with the organic content, and only at those stations where sand predominated were levels below M.O.E. guidelines (Table 3.2.2). Levels of Fe were consistently above M.O.E. guidelines, even at those stations where other contaminant levels were low.

Located in a boat docking bay off the main stream, station 2846 was the furthest upstream area sampled. Sediments were high in silt (72%), though only moderately high in organic content and contaminant levels (3 of the 8 for which guidelines were available exceeded the prescribed levels; Table 3.2.2).

Station 2841, located in Oakville Creek, was also in an area of high silt content (49%), while sand and gravel comprised most of the remainder (19% and 16% respectively). Organic content, though high, was lower than at station 2840, as were contaminant levels.

Station 2842, located approximately 200 m downstream from station 2841, was also similar in sediment type (Table 3.2.2), differing in a slightly higher sand fraction and a slightly reduced organic content. Levels of most contaminants were lower than at station 2841 except for solvent extractables (Table 3.2.2) which, though still below M.O.E. guidelines, were the highest of any of the stations.

Station 2843, located approximately 200 m downstream of station 2842, was situated in predominantly sandy sediments (54%) low in organic content. Contaminant levels were also correspondingly low with none of the parameters exceeding the guidelines.

Station 2844, located in a boat docking area off the main river channel similar to station 2840, had a similarly high silt content and hence a similar organic content (Table 3.2.2). The contaminant levels were also elevated and compared closely with levels at station 2840.

Located in the same boat docking area as station 2844, station 2845 yielded only minor differences in sediment organic content, which was lower as a result of the reduced silt content of the sediments (55%, Table 3.2.2). Located closer to the docking area entrance, it may have been subjected to eddy currents, resulting in less deposition of fine sediments than was occurring further back in the bay (station 2844). Contaminant levels were also lower than at station 2844 and most were below the guidelines.

Station 2846 was located at the base of the breakwater in a depositional environment. Sediments were mainly silts (52%) and sand (30%) and contained a moderate level of organic matter. Contaminant levels were moderate, though in a few instances (Cu and Fe) they did slightly exceed M.O.E. guidelines.

Station 2847, located in deeper water in the main channel, was in an area of mainly sand substrate (60%) with some silt (23%) and generally low in organic content. Typical of sandy areas, sediment contaminant levels were low, reflecting the inability of sandy, erosional areas to retain significant levels of these contaminants (Mudroch & Duncan 1986).

Located in the constricted mouth of the channel, station 2848 was situated in a highly erosional area as evidenced by both the sandy sediments and the increased turbidity and suspended particle load of the water (Table 3.2.1). Contaminant levels were also low at this station, for the same reasons as discussed earlier for station 2847.

Benthic Invertebrates

Located in a boat docking bay off the main stream, station 2846 was the furthest upstream area sampled. Sediments were high in silt (72%) and the benthic community consisted almost entirely of fine particle feeders, especially sizeable oligochaete and chironomid communities (Table 3.2.4). Predators (Polycentropus) and grazers (Gammarus fasciatus) comprised a total of only 1% of the fauna. The fine sediment fauna, which consisted almost exclusively of Limnodrilus spp., and the chironomid Chironomus plumosus, were indicative of organically enriched areas. This community comprised 99% of the density and biomass in this area (Table 3.2.3).

Station 2841, located in Oakville Creek, was also in an area of high silt content (49%) while sand and gravel comprised most of the remainder (19% and 16% respectively). The benthic community was similar to the one

at station 2840 and was comprised mainly of fine sediment feeders (primarily oligochaetes) which accounted for 99% of the fauna. A small population of predators (Cryptochironomus and Procladius) and epibenthic grazers (Asellus and Gammarus fasciatus) constituted the remaining 1%. The fauna, though slightly more diverse than at the preceding station, was still typical of organically enriched areas and was dominated by Limnodrilus spp., Chironomus plumosus and Procladius, all indicative of somewhat polluted conditions.

Station 2842, located approximately 200 m further downstream, was in a similar, though slightly sandier, area. The benthic community was also similar in that the oligochaetes still formed the largest faunal group, but was more diverse in terms of the other groups present. This increase was mainly in lotic species such as Hydropsyche, Chimarra, and the elmids. The sediment deposit feeders still formed the largest group (99%) and consisted mainly of the Tubifex tubifex - Limnodrilus community. This, coupled with the small fraction of predators (Chimarra, Procladius), filterers (Hydropsyche), and grazers (Gammarus fasciatus) indicated that organic content and sediment composition were still the major determinants of the fauna.

Station 2843, located approximately 200 m downstream of station 2842, was situated in predominantly sandy sediments (54%). The benthic community, though reduced in density (Table 3.2.4) in comparison to the upstream areas, was similar in faunal composition. The oligochaetes T. tubifex and Limnodrilus spp., and chironomids (Chironomus and Microtendipes), comprised the fine sediment feeders and again this group constituted 99% of the total faunal density.

Station 2844, like station 2840, was located in a boat docking area off the main river channel. Silt content and organic content were both as high as at station 2840 (Table 3.2.2). The benthic community differed little in diversity of organisms (Table 3.2.4), though average density was somewhat higher at station 2844 (Table 3.2.3). The oligochaete-chironomid fauna noted earlier also dominated the benthos at this station.

Located in the same boat docking area as station 2844, station 2845 yielded only minor differences in sediment organic content, which was lower as a result of the reduced silt content of the sediments (55%). Located closer to the entrance to the docking area, it may have been subjected to current action, resulting in less deposition of fine sediments than was occurring further back in the bay (station 2844). These types of current effects (as denoted by the increased turbidity and sediment load, Table 3.2.1) may also have enabled such species as Hydropsyche and Stenelmis to establish a foothold in this area since both of these are strongly rheophilic. Despite these minor additions (together they comprised less than 0.5% of the fauna), the major part of the fauna was still sediment fine particle feeders (87%), primarily the Tubifex tubifex, Limnodrilus, and Chironomus plumosus community. Predators (Procladius) were the only other major group, and constituted 12% of the fauna.

Station 2846 was located at the base of the breakwater in a

depositional environment. Sediments were mainly silts (52%) and sand (30%) and the benthic fauna differed from the previous stations only in the density and biomass of organisms, both of which were considerably higher than at the other areas sampled. This station was also the shallowest area sampled and the increased density could be attributable to the littoral habitat. As Cook & Johnson (1974) pointed out, littoral areas tend to be much more productive than deeper areas. Faunal composition at this station however, was virtually unchanged, and consisted of the Tubifex tubifex, Limnodrilus spp., and Chironomus plumosus community typical of organically enriched areas.

Station 2847, located in deeper water in the main channel, yielded a density more consistent with the results from the upstream stations. While substrate was mainly sand (60%) with some silt (23%), the benthic community consisted almost entirely of oligochaetes or their predators (Cryptochironomus), though the oligochaete community (Table 3.2.4) was more diverse than at the upstream stations, and reflected the decreased organic content and sandier substrate. The T. tubifex - Limnodrilus community had apparently been supplanted by a fauna more typical of less organically enriched areas (Brinkhurst 1970).

Located in the constricted mouth of the channel, station 2848 was situated in a highly erosional area as evidenced by the sandy sediments and increased turbidity and suspended particle load of the water (Table 3.2.1). The extremely reduced benthic fauna (Table 3.2.4) reflected the erosional conditions, and was not an indication of contaminants in the sediments, which were present at low levels.

In summary, the faunal density and species composition of the benthic community in Oakville Creek seemed to be determined by the physical, rather than chemical, features of the creek. Sediment organic content and, closely associated with this, sediment type appeared to be the main factors, though depth and no doubt oxygen content also played significant roles. Sediment contaminant levels were all moderately low and appeared to have little effect upon the fauna.

Summary

1) Nearly all of the stations were located in depositional environments. Sediments appeared to be mainly fine organic particles, which in turn determined the type of benthic community.

2) Exceptions were stations 2847 and 2848, both of which were in erosional areas at the mouth of the creek. Sediments were mainly sand and, as a result, density and diversity of benthic organisms was low.

3) Sediment contaminant levels were low at all areas sampled and appeared to have no effect upon the benthic fauna either in terms of density or diversity.

4) Organic content of the sediments appeared to be the single most important factor determining benthic faunal composition and density.

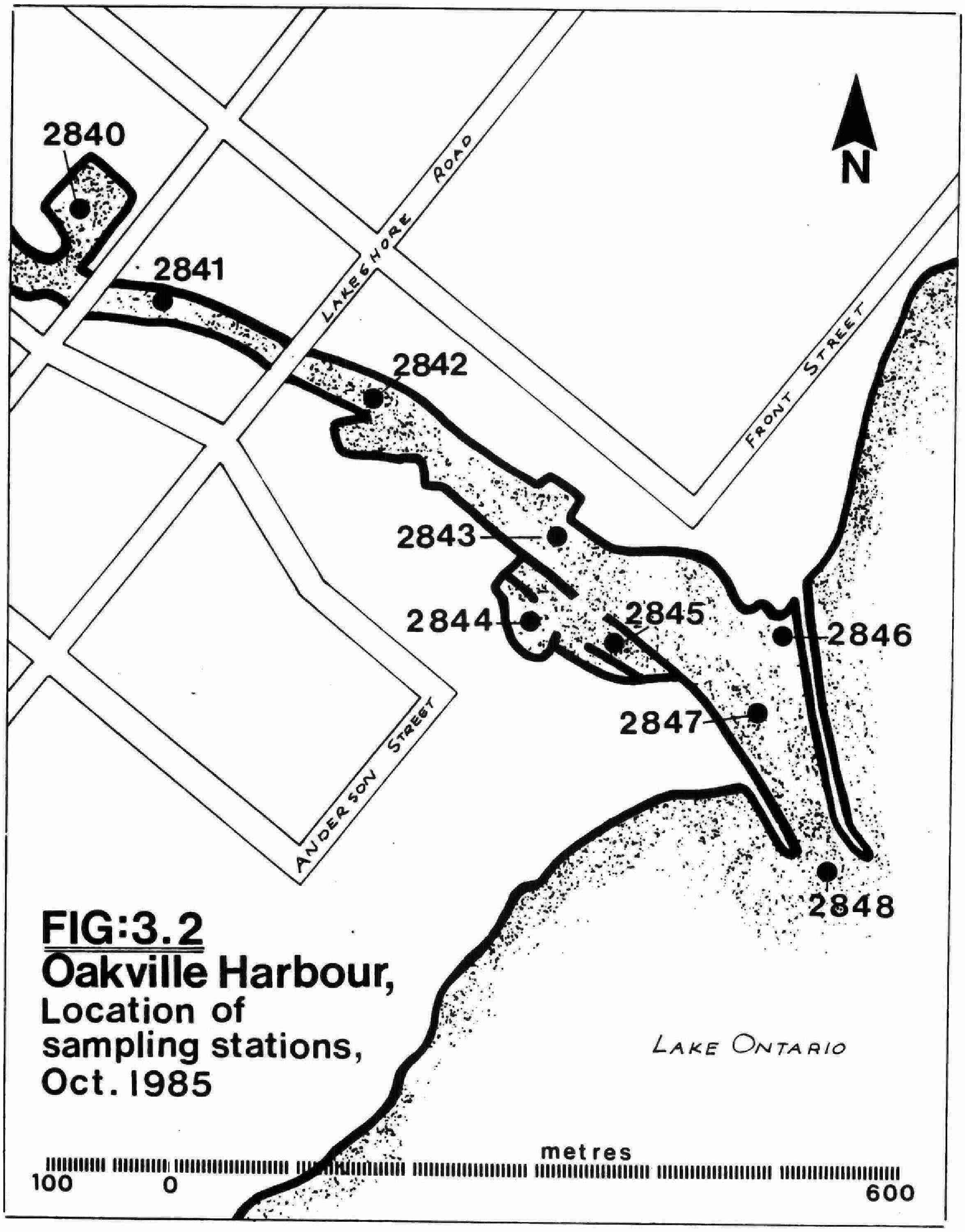

FIG:3.2
Oakville Harbour,
Location of sampling stations, Oct. 1985

TABLE 3.2.1. WATER QUALITY DATA - OAKVILLE HARBOUR. (TAKEN 1 M OFF BOTTOM).

Station Number	pH	Hardness (mg/l)	Chemical Oxygen Demand (COD) (mg/l)	Dissolved Organic Carbon (DOC) (mg/l)	Total Kjeldahl Nitrogen (TKN) (mg/l)	Turbidity	Suspended Particulate (mg/l)	Sodium (Na) (mg/l)	Chloride (Cl) (mg/l)
2840	8.27	202.0	30.7	6.3	0.85	61.00	91.52	17.00	29.80
2841	8.26	200.5	24.6	6.3	0.75	55.00	26.65	18.30	33.65
2842	8.33	173.5	25.5	6.2	0.77	44.00	25.77	16.90	30.10
2843	8.30	205.0	24.6	6.1	0.73	40.00	24.75	16.60	30.05
2844	8.47	178.5	23.9	6.5	0.81	41.00	41.01	16.70	29.85
2845	8.24	195.5	27.8	5.8	0.86	136.00	118.40	16.10	28.55
2846	8.19	210.0	25.9	6.0	1.04	67.00	52.03	16.60	29.10
2847	8.27	141.5	30.4	5.5	1.05	148.00	241.50	14.90	25.85
2848	8.22	154.0	30.9	5.6	1.00	153.00	274.50	15.40	27.00

TABLE 3.2.2. SEDIMENT DATA - OAKVILLE HARBOUR.

Station Number	Grain Size (%) Gravel/Sand/Silt/Clay	Total Organic Carbon (TOC) (mg/g)	Loss on Ignition (LOI) (%)	Total Phosphorus (TP) (mg/g)	Total Kjeldahl Nitrogen (TKN) (mg/g)	Solvent Extractables (ug/g)
2840	0/11/72/15	18.0	3.40	0.89	1.00	925.0
2841	16/19/50/14	13.0	2.20	0.86	0.80	521.0
2842	0/42/43/13	10.0	1.80	0.63	0.60	1,180.0
2843	0/54/34/10	2.4	1.10	0.64	0.30	308.0
2844	0/11/74/13	15.0	3.50	0.84	0.90	864.0
2845	0/27/56/14	11.0	2.70	0.76	0.80	726.0
2846	0/30/52/11	13.0	2.30	0.81	0.70	557.0
2847	0/61/23/15	< 5.0	0.69	0.60	0.20	172.0
2848	0/76/15/8	< 5.0	0.35	0.73	0.10	244.0

Station Number	Cu (ug/g)	Cr (ug/g)	Hg (ug/g)	Fe (ug/g)	As (ug/g)	Zn (ug/g)	Al (ug/g)	Total PCB's (ug/kg)
2840	52.0	32.0	0.22	27,000.0	6.47	220.0	17,000.0	30
2841	36.0	27.0	0.06	27,000.0	6.10	130.0	16,000.0	20
2842	27.0	25.0	0.07	21,000.0	4.41	100.0	12,000.0	< 20
2843	19.0	17.0	0.03	17,000.0	3.05	71.0	9,200.0	< 20
2844	39.0	60.0	0.04	24,000.0	5.73	130.0	15,000.0	< 20
2845	29.0	29.0	0.04	22,000.0	4.90	100.0	13,000.0	< 20
2846	28.0	22.0	0.03	20,000.0	4.34	93.0	12,000.0	30
2847	17.0	17.0	0.01	18.000.0	3.60	67.0	9,300.0	< 20
2848	20.0	17.0	0.04	19,000.0	2.52	56.0	6,000.0	< 20

TABLE 3.2.3. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA - OAKVILLE HARBOUR.

All values are expressed as #'s per square meter.

	Station #2840		Station #2841		Station #2842	
	Average # Organisms	**Biomass (gms)**	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera			8	0.0797	5	0.0146
O. Trichoptera	3				8	
O. Coleoptera	3	0.0012			3	
O. Diptera						
F. Chironomidae	467	0.9048	258	0.2474	102	0.0866
O. Lepidoptera						
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	3		36	0.0150	29	0.0163
O. Isopoda			5		5	
MOLLUSCA						
Class Gastropoda					1	0.0693
Class Pelecypoda	3		3	0.0127	3	0.0106
NEMATOMORPHA						
ANNELIDA						
Class Oligochaeta	1,432	2.3871	3,135	4.6798	7,174	16.0304
TOTAL # ORGANISMS	1,911		3,445		7,330	
TOTAL BIOMASS		3.2931		5.0346		16.2278
CORRECTED BIOMASS (+10%)		3.6224		5.5381		17.8506

TABLE 3.2.3. (Continued)

All values are expressed as #'s per square meter.

	Station #2843		Station #2844		Station #2845	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera						
O. Trichoptera					3	
O. Coleoptera	1		1		1	0.0044
O. Diptera						
F. Chironomidae	62	0.0353	550	0.7164	264	0.4070
O. Lepidoptera					1	
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	6	0.0146	5	0.0012	9	0.0175
O. Isopoda					1	
MOLLUSCA						
Class Gastropoda	1	0.0056			4	0.0033
Class Pelecypoda	1	0.0057			5	0.0079
NEMATOMORPHA					9	0.0031
ANNELIDA						
Class Oligochaeta	1,615	3.8119	2,518	4.3332	1,981	2.9246
TOTAL # ORGANISMS	1,686		3,074		2,274	
TOTAL BIOMASS		3.8732		5.0508		3.3678
CORRECTED BIOMASS (+10%)		4.2605		5.5559		3.7046

TABLE 3.2.3. (Continued)

All values are expressed as #'s per square meter.

Station #2846		Station #2847		Station #2848	
Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
411	0.9568	32	0.0274	11	0.0034
8	0.0077	6	0.0071	3	0.0005
		1	0.0104		
3	0.2938				
10,254	7.0044	1,071	0.3918	45	0.0076
10,676		1,110		59	
	8.2627		0.4367		0.0115
	9.0890		0.4804		0.0126

TABLE 3.2.4. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - OAKVILLE HARBOUR.

	STATION NUMBER (#/m²)								
SPECIES	2840	2841	2842	2843	2844	2845	2846	2847	2848
EPHEMEROPTERA:									
Caenidae:									
Caenis sp.			11						
Ephemeridae:									
Ephemera simulans		15							
TRICHOPTERA									
Hydropsychidae:									
Hydropsyche sp.			11			8			
Philopotamidae:									
Chimarra sp.			11						
Polycentropodidae:									
Polycentropus sp.	8								
COLEOPTERA									
Elmidae:									
Stenelmis sp.			4	4		4			
Dubiraphia sp.			4		4				
DIPTERA									
Chironomidae:									
Cryptochironomus sp.		31	15	4			8	46	13
Chironomus plumosus group	452	77	15	15	65	123	253	4	
Endochironomus sp.					11				
Microtendipes sp.				4					
Procladius sp.		153	4	34	272	310	84		
AMPHIPODA									
Gammaridae:									
Gammarus fasciatus	8	61	73	4		4	8		4
ISOPODA									
Asellidae: Asellus sp.		15	15			4			
GASTROPODA									
Hydrobiidae:									
Amnicola limosa						8			
PELECYPODA									
Sphaeriidae:									
Sphaerium striatinum						4			
Pisidium casertanum	8					8			
OLIGOCHAETA									
Tubificidae:									
Tubifex tubifex			134	107	119	107	1,900		
Aulodrilus pleuriseta						107			
Potamothrix moldaviensis								46	
Quistadrilus multisetosus		123	73			107		46	
Limnodrilus hoffmeisteri	582	643	264	329	291		1,164	46	
L. udekemianus				54	57		1,164		
L. cervix	214	123				230			
L. claparedeianus	291						368		
Immatures with capilliform setae		123	134	107	172				
Immatures without capilliform setae	360	1,164	938	551	582	1,486	4,228	1,065	23
Enchytraeidae: sp. indet.								138	
Total Number of Organisms	1,923	2,528	1,706	1,213	1,573	2,510	9,177	1,391	46
Species Diversity (H')	2.33	2.48	2.47	2.18	2.49	2.07	2.15	1.30	1.33
Species Richness (S.R.)	1.13	1.84	2.60	1.74	1.33	2.01	1.03	1.02	0.81
Evenness (J')	0.77	0.67	0.60	0.63	0.78	0.54	0.68	0.46	0.84

3.3. PORT WELLER HARBOUR

Introduction

The harbour at Port Weller serves as the northern terminus of the Welland Canal. The canal itself carries a significant amount of ship traffic and is subjected to contaminants originating with this use. In addition, the canal has received inputs of contaminants from local industries located along its banks. Sediment input from the surrounding agricultural areas is also significant. Areas outside the harbour may also be subject to effects from industries and domestic sewage treatment operations in nearby St. Catherines.

Water Quality

Waters in and around Port Weller Harbour were characterized as hard, of moderately high pH, and low in organic matter (Table 3.3.3). Turbidity and suspended particle load were low, though the latter was rather variable.

Sediment Quality

Only six of the projected ten stations were sampled in this area (Fig. 3.3). The remaining four stations were in areas of hard substrate that precluded sampling by Ponar. Sediments at only a few stations (2440 and 2839) were silts or silty sands (Table 3.3.4), and these areas were the only ones with any significant levels of organic matter. Contaminant levels were generally low in sandy areas (the exception was Fe) and increased with increasing organic content. Levels were highest at station 2839, where 6 of the 8 parameters listed in Table 3.3.2 exceeded M.O.E. guidelines.

Station 2431 was located close to shore in Lake Ontario, west of Port Weller. Substrate was almost entirely sand, low in organic content (Table 3.3.4) and low in contaminant levels. The exceptions were Fe and Zn, both of which were relatively high considering the high sand content.

Station 2435, located approximately 1 km east of station 2431 at the base of the headland, was in a similarly sandy area (96%) very low in organic matter. While sediment texture (grain size) was nearly identical to station 2431, Fe and Zn levels in particular, and all contaminants in general, were lower.

Sediment data were lacking for station 2438, located in the mouth of the harbour, though this appeared to be an erosional area as well, as indicated by the benthic fauna.

Station 2440 was located in Lake Ontario approximately 2 km northeast of the Port Weller Harbour entrance. Sediments were a sand-silt mix (47%-43%) with a moderate organic content. Contaminant levels for most parameters were moderately high and most were at or above the guidelines. PCBs, which at 230 ug/kg were nearly 5 times M.O.E. guidelines, were the

highest.

Station 2444, located near shore east of the headland, was also in an erosional area. Substrate was mainly sand (91%) and very low in organic matter. Except for Fe, all parameters listed in Table 3.3.2 were below the M.O.E. guidelines.

Located inside the harbour itself, station 2839 was situated in a depositional zone. Fine sediments (silts - 67% and clays - 28%) formed most of the substrate and as a result, organic content was moderately high. Levels of contaminants were also higher than at any of the other stations, and of the 8 parameters listed in the tables, 6 exceeded the guidelines, with some (PCBs) up to 5 times higher.

Benthic Invertebrates

Most of the stations in and around the harbour were in sandy areas and this factor considerably influenced the composition of the benthic fauna at these locations. The first of these, station 2431 was located close to shore in Lake Ontario, west of Port Weller. The benthic fauna was very reduced in both density and biomass (Table 3.3.3) and consisted solely of a small population of chironomids and amphipods. The small population size was likely a direct effect of the very low organic content of the sediments which, additionally, were unable to support an oligochaete community.

Station 2435, located approximately 1 km east of station 2431 at the base of the headland, was in a similarly sandy area (96%) very low in organic matter. Water quality data indicated a reduced current in this area (reduced suspended particle load; Table 3.3.1) and this was likely the main factor in the larger benthic fauna, which was almost entirely comprised of fine sediment feeders (Pisidium, Chironomus, and oligochaetes). Predators (Cryptochironomus) were the only other significant group.

Though sediment data were lacking for station 2438, located at the mouth of the harbour, this appeared to be an erosional area as well. The reduced fauna indicated that a low amount of organic matter was available in this area to sustain benthic population growth. Most of the fauna were fine sediment feeding species, such as the oligochaetes and sphaeriid clams, with the remainder of the fauna (2.4%) grazers on coarse organic detritus (Gammarus fasciatus).

Station 2440 was located in Lake Ontario approximately 2 km northeast of the Port Weller Harbour entrance. Sediments were a sand-silt mix (47%-43%) with a moderate organic content. A large and diverse benthic fauna occurred in this area, and though oligochaetes comprised the largest fraction, the most common species was Quistadrilus multisetosus (Tables 3.3.3 & 3.3.4), a species common in sandy areas. Sediment fine particle feeders comprised 72% of the fauna with the remainder made up of the grazers Pontoporeia hoyi, Asellus, and Amnicola limosa (17%), and the predators Procladius and Cryptochironomus (11%). Noteworthy was the presence of the amphipod P. hoyi, a common component of deeper,

oligotrophic areas of the Great Lakes. In all, this area yielded one of the largest, most diverse faunas of any of the stations sampled.

Station 2444, located in a near-shore area east of the headland, was again in an erosional area. Substrate was mainly sand (91%) and very low in organic matter. The benthic fauna was severely reduced and favoured those organisms preferring sandy areas, such as the naidid worms. Few sediment feeders were present, a reflection of the low organic content and unsuitable sediment and current conditions. Both this station and station 2431 appeared to be in the wave zone, an area Barton (1986) noted tended to be reduced in fauna due to the rather severe physical conditions of this environment.

Located inside the harbour itself, station 2839 was situated in a depositional zone. Fine sediments (silts - 67% and clays - 28%) formed most of the substrate and, as a result, organic content was moderately high. The benthic fauna reflected the fine organic sediment, being comprised primarily of fine sediment feeders (99%) of which oligochaetes formed the major fraction (90%). The species present were also typical of eutrophic areas, and consisted mainly of the <u>Tubifex tubifex</u> - <u>Limnodrilus hoffmeisteri</u> community often associated with organically enriched areas. Contaminant levels, though higher than at any other station, appeared to have little effect on the fauna.

In summary, the benthic fauna appeared to be primarily determined by substrate composition and organic content. The near-shore areas (stations 2431, 2435, and 2444) as well as the harbour entrance (station 2438) appeared to be highly erosional and consisted mainly of sandy substrate low in organic matter and contaminant levels. Benthic faunal density and diversity were correspondingly low.

The harbour itself appeared to be a depositional area of high fine sediment content and hence a high organic content. A typical soft sediment benthic community comprised of oligochaetes and chironomids was common here.

The offshore area (station 2440) was typical of sandy-silty substrates of Lake Ontario (see preceding sections).

Toxic effects appeared to be lacking entirely. Contaminant levels were at most 2.5 times higher (except PCBs) than the M.O.E. guidelines at the most seriously contaminated area (station 2839) and had no apparent effect on the already organically stressed fauna.

<u>Summary</u>

1) Sediments were mainly sand and gravel and appeared to be in the wave-washed zone close to the shoreline. The benthic fauna, as a result, was severely reduced and consisted of only a few species. Community structure appeared to follow no patterns and consisted only of those individuals that were able to establish populations at these locations.

2) Areas inside the harbour (station 2839) were depositional in nature, and sediments consisted of fine organic particles. The benthic fauna was also typical of fine sediment areas and consisted primarily of oligochaetes and chironomids.

3) Offshore areas (outside of the wave-zone) had a typical mesotrophic fauna which reflected the sandy substrate and low organic content.

4) Contaminant levels were low at most areas and appeared to have no effect on the benthos.

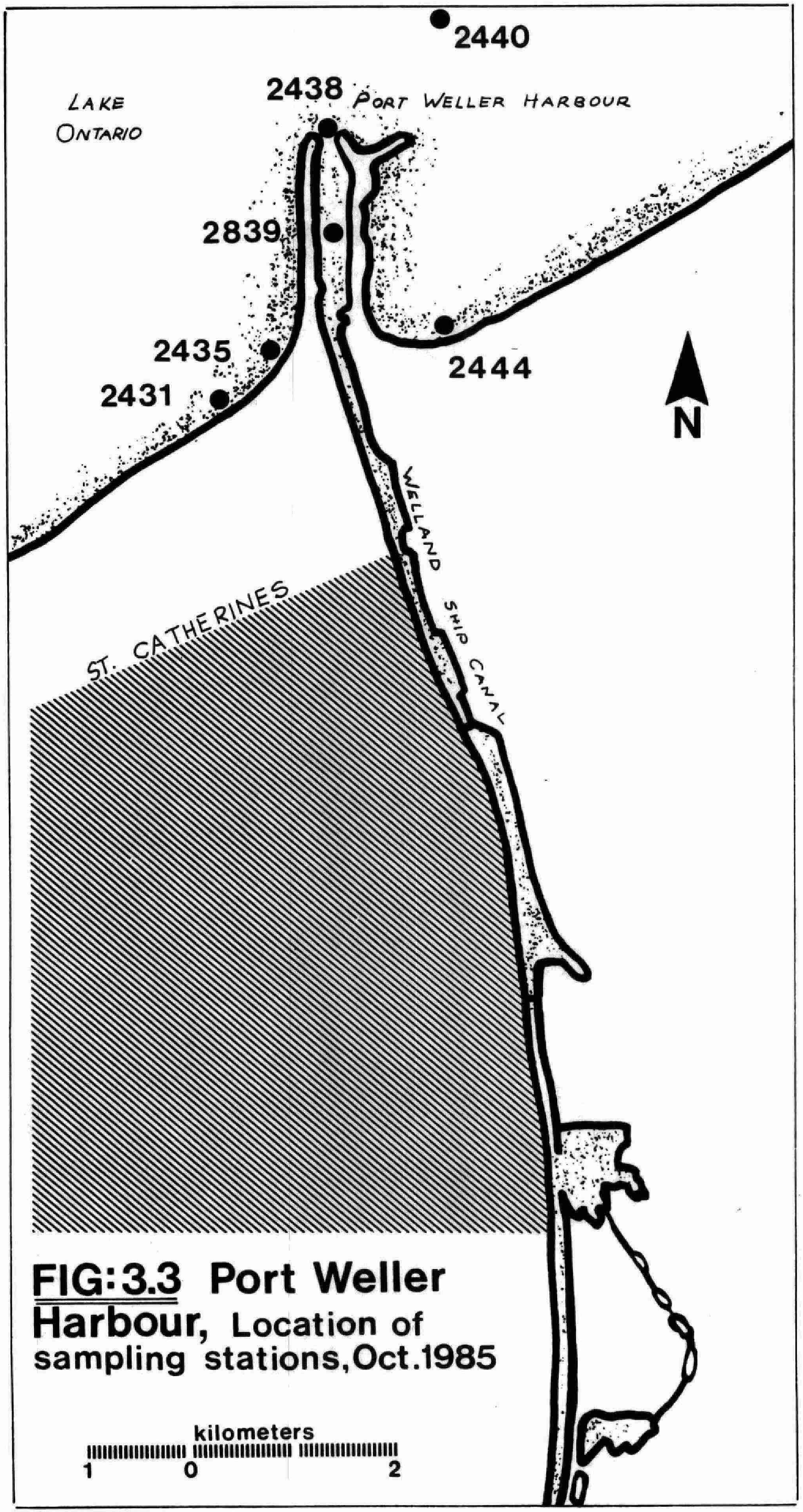

FIG:3.3 Port Weller Harbour, Location of sampling stations, Oct.1985

TABLE 3.3.1. WATER QUALITY DATA - PORT WELLER HARBOUR. (TAKEN 1 M OFF BOTTOM).

Station Number	pH	Hardness (mg/l)	Chemical Oxygen Demand (COD) (mg/l)	Dissolved Organic Carbon (DOC) (mg/l)	Total Kjeldahl Nitrogen (TKN) (mg/l)	Turbidity	Suspended Particulate (mg/l)	Sodium (Na) (mg/l)	Chloride (Cl) (mg/l)
2431	8.31	131.5	8.7	2.7	0.320	20.00	23.70	10.50	19.10
2435	8.29	144.5	10.2	2.2	0.370	33.00	5.78	11.30	20.90
2438	8.30	137.0	11.3	2.7	0.350	34.00	31.25	12.00	20.65
2440	8.25	129.0	5.1	2.0	0.290	12.60	41.39	11.12	22.70
2444	8.26	127.0	19.8	2.3	0.300	15.20	17.87	9.74	-
2839	8.24	137.0	8.9	2.7	0.370	56.00	44.91	12.57	20.10

TABLE 3.3.2. SEDIMENT DATA - PORT WELLER HARBOUR.

Station Number	Grain Size (%) Gravel/Sand/Silt/Clay	Total Organic Carbon (TOC) (mg/g)	Loss on Ignition (LOI) (%)	Total Phosphorus (TP) (mg/g)	Total Kjeldahl Nitrogen (TKN) (mg/g)	Solvent Extractables (ug/g)
2431	0/96/2/1	< 5.0	0.19	0.69	5.50	57.0
2435	0/96/2/1	< 5.0	0.29	0.43	0.50	-
2438	-	-	-	-	-	-
2440	1/47/43/8	7.8	2.10	0.85	1.60	569.0
2444	0/92/7/1	< 5.0	0.39	0.50	0.90	72.0
2839	0/4/67/28	14.0	2.80	1.46	2.10	1,266.0

Station Number	Cu (ug/g)	Cr (ug/g)	Hg (ug/g)	Fe (ug/g)	As (ug/g)	Zn (ug/g)	Al (ug/g)	Total PCB's (ug/kg)
2431	11.0	21.0	0.01	11,000.0	1.67	70.0	3,100.0	< 20
2435	9.9	8.7	0.01	6,000.0	1.53	33.0	2,900.0	< 20
2438	-	-	-	-	-	-	-	-
2440	36.0	35.0	0.13	17,000.0	4.74	100.0	9,600.0	230 P84
2444	16.0	22.0	0.01	20,000.0	3.61	25.0	4,600.0	< 20
2839	55.0	55.0	0.10	25,000.0	6.68	250.0	17,000.0	255 P84

TABLE 3.3.3. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA = PORT WELLER.

All values are expressed as #'s per square meter.

	Station #2431		Station #2435		Station #2438	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera						
O. Trichoptera						
O. Diptera						
F. Chironomidae	47	0.0305	46	0.061		
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	3	0.0009	1		2	
O. Isopoda						
MOLLUSCA						
Class Gastropoda			1	0.0108	2	
Class Pelecypoda			3	0.01212	54	0.0386
COELENTERATA						
NEMATODA						
PLATYHELMINTHES						
Class Turbellaria					6	
ANNELIDA						
Class Hirudinea						
Class Oligochaeta			157	0.078	57	0.02
TOTAL # ORGANISMS	50		208		121	
TOTAL BIOMASS		0.0314		0.1619		0.0586
CORRECTED BIOMASS (+10%)		0.03454		0.1781		0.0645

TABLE 3.3.3. (Continued)

All values are expressed as #'s per square meter.

	Station #2440		Station #2444		Station #2839	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera	5					
O. Trichoptera			4	0.0039		
O. Diptera						
F. Chironomidae	186	0.2918	34	0.0215	46	0.058
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	186	0.2666	5			
O. Isopoda	15	0.0038				
MOLLUSCA						
Class Gastropoda	112	1.1856			37	0.4447
Class Pelecypoda	283	2.7833	8		6	0.0213
COELENTERATA			54	0.0066		
NEMATODA					1	
PLATYHELMINTHES						
Class Turbellaria			1			
ANNELIDA						
Class Hirudinea					11	0.0759
Class Oligochaeta	661	0.5078	10	0.00023	1,686	2.7656
TOTAL # ORGANISMS	1,448		116		1,787	
TOTAL BIOMASS		5.0389		0.0343		3.3655
CORRECTED BIOMASS (+10%)		5.5428		0.0377		3.7021

TABLE 3.3.4. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - PORT WELLER.

SPECIES	STATION NUMBER (#/m²)					
	2431	2435	2438	2440	2444	2839
EPHEMEROPTERA:						
Ephemerellidae:						
Eurylophella sp.				15		
TRICHOPTERA						
Polycentropodidae:						
Polycentropus sp.					4	
DIPTERA						
Chironomidae:						
Cryptochironomus sp.	23	46		77		31
Chironomus thummi group	42	4		46		8
Paratanytarsus sp.					19	
Procladius sp.				92		4
AMPHIPODA						
Haustoridae:						
Pontoporeia hoyi	4			214		
Gammaridae:						
Gammarus fasciatus			4		15	
G. pseudolimnaeus		4				
ISOPODA						
Asellidae: Asellus sp.				15		
GASTROPODA						
Valvatidae:						
Valvata sincera				46		54
V. tricarinata				31		
Pleuroceridae						
Goniobasis livescens				15		
Hydrobiidae:						
Amnicola limosa			4	46		
Marstonia decepta				31		
PELECYPODA						
Sphaeriidae:						
Sphaerium corneum				92		
S. striatinum			8			8
Pisidium casertanum			46	245	23	
P. ventricosum		4				
HIRUDINEA						
Helobdella stagnalis						11
OLIGOCHAETA						
Naididae: sp. indet.					4	
Enchytraeidae: sp. indet.			19			
Lumbriculidae:						
Stylodrilus heringianus			4			
Tubificidae:						
Tubifex tubifex						61
Quistadrilus multisetosus			27	659		
Spirosperma ferox			15			124
Limnodrilus hoffmeisteri						368
L. claparedeianus						123
L. udekemianus			4			
Immatures with capilliform setae		245				306
Immatures without capilliform setae			38	61	4	490
Total Number of Organisms	69	303	169	1,685	69	1,648
Species Diversity (H')	1.19	0.90	2.79	2.97	2.22	2.67
Species Richness (S.R.)	0.69	0.92	2.38	2.30	1.73	1.82
Evenness (J')	0.75	0.39	0.84	0.76	0.86	0.74

3.4. BAY OF QUINTE

Introduction

The Bay of Quinte has, over many decades, received a variety of organic and chemical inputs (Minns et al 1986). Organic enrichment has been effected though non-point source inputs, mainly as a result of deforestation and agricultural practices. Domestic sewage plants have also contributed to this problem in both the Trenton and Belleville areas. Contaminants have arisen as a result of all of these, as well as local manufacturing and, historically at least, through mining as well.

Water Quality

Sampling stations in the Bay of Quinte were localized around Trenton (five stations) and Belleville (five stations) and were situated along the waterfront areas of both of these cities (Fig. 3.4).

The first five stations were located at the western end of the Bay of Quinte at Trenton. Water quality along the Trenton waterfront was characterized by moderately hard water and high pH values (Table 3.4.3). Organic matter was relatively high at most stations. Turbidity and the suspended particle load were low as were levels of salts (Na and Cl).

The remaining five stations were all located at Belleville (Fig. 3.4). Water quality parameters (Table 3.4.3) bore no major difference to those described for the Trenton waterfront area.

Sediment Quality

Sediments at Trenton were mainly sand (mostly coarse sand) with variable amounts of silt. Organic content was variable and depended upon the silt content of the sediments (Table 3.4.4), though organic levels were very high at station 0156 when considered in light of the high sand content.

Station 0125, located in the Trent River, was situated in an area of sand substrate (94%) low in organic content. Levels of most contaminants were low, with the exception of Cr and Zn, which exceeded M.O.E. guidelines by 8 and 4.4 times respectively (Table 3.4.4). Though just under the limit, solvent extractables were also high, and all three were very high when the low sediment organic content is taken into account.

Station 0346, located in the Bay of Quinte at the mouth of the Trent River, was also in an area of mainly sandy substrate. Silt, however, formed a larger fraction of the sediment than at the preceding area and this was reflected in the higher organic content of the sediment. Despite the higher organic content, levels of contaminants were low, and none of the parameters listed in Table 3.4.2., with the exception of PCBs, exceeded the guidelines.

Station 0140 was located near the eastern end of Trenton opposite a

sewage treatment plant. Though sediment data were lacking for this station, the composition of the benthic community suggests that this was also an area of sandy substrates, low in organic matter.

Organic matter was very high at station 0156, despite the mainly sandy (61%) sediment. Contaminant levels were only moderately high with most parameters at or slightly above M.O.E. guidelines (Table 3.4.4). The exceptions were solvent extractables and PCBs, both of which were approximately 2 times higher than M.O.E. guidelines. Pesticide levels were high, especially levels of dieldrin (70 ng/g), DMDT methoxyclor (420 ng/g), endrin (280 ng/g) and endosulfan sulphate (140 ng/g).

Station 0161, located along the north shore east of Trenton, was also situated offshore from a sewage treatment plant. Sediments in this area were mainly sand and gravel (85%), low in both silts and organic content. Contaminant levels were all correspondingly low and none exceeded the guidelines.

The remaining five stations were all located at Belleville (Fig. 3.4). Sediment analysis (Table 3.4.2) revealed that substrates were primarily silts in this area (except for station 0199), very high in organic content. Levels of contaminants were also high, though most were less than 2 times above the allowable limits. Some, such as PCBs, solvent extractables and Zn, were disproportionately higher than the other parameters and at some stations the former two exceeded limits by 4 - 6 times.

Station 0181 was located just east of the mouth of Belleville Harbour in an area of silty sediments, very high in organic matter. Solvent extractables, PCBs, and Zn were all high (Table 3.4.2), though guidelines were exceeded for all of the parameters for which these have been set.

Sediment data were lacking for station 0182, but the benthic community composition suggested that sand and gravel formed much of the substrate here.

Station 0192 was located further out into the bay, opposite station 0182. Sediments were mainly silts (60%), with some clay (14%) and sand (24%) and were high in organic content. While contaminant levels generally were elevated, levels of PCBs and hydrocarbons were disproportionately higher (Table 3.4.4). As at station 0181, levels exceeded guidelines for all the parameters. Of the pesticides, DMDT methoxyclor levels were high (515 ng/g)

Station 0195, located 2 km east of station 0192, was situated in a similarly organic area, high in silt (64%) and organic content (TOC and LOI). Contaminant levels were again high and Cu, As, Zn, PCBs and solvent extractables were the highest of any station in the Bay of Quinte (Table 3.4.4).

Station 0199, located in sandy sediments in a bay at the east end of Belleville, had a lower organic content and contaminant levels than any of the preceding stations. All of the parameters were well below M.O.E.

guidelines.

Benthic Invertebrates

The first five stations in Table 3.4.3 were all located around Trenton and were generally in areas of sandy substrates. This was reflected in the composition of the benthic community which, at each station, was low in density of the fine sediment infauna (Table 3.4.4).

Station 0125, located in the Trent River, was situated in an area of sand substrate (94%) low in organic content. This area yielded a very diverse benthic fauna of lotic (Trichoptera and Coleoptera, Table 3.4.4) and lentic species. Overall density and biomass were low, reflecting the low organic content of the sediments. The lotic fauna was represented by Cheumatopsyche, Polycentropus, and Stenelmis, all of which are more or less rheophilic. Oligochaetes were noticeably sparse and were represented by Quistadrilus multisetosus, a species common in sandy substrates. In all, fine sediment feeders (oligochaetes) comprised 0.04% of the fauna. The largest single fraction was the grazer population, which comprised over 98% of the fauna and consisted of grazers on both coarse detritus as well as macrophytes (termed gathers by Merritt & Cummins (1978)). The remainder of the population consisted of filterers (0.03%) and predators (0.8%). Evidently much of the organic matter in this area was coarse detritus.

Station 0346, located in the Bay of Quinte at the mouth of the Trent River, was also in an area of mainly sand substrate. Silt, however, formed a larger fraction of the sediment than at the preceding area and this was reflected in the higher organic content of the sediment. Benthic density and biomass (Table 3.4.3) were similar to station 0125, though a shift to a larger oligochaete fauna was evident. The fine sediment feeders (oligochaetes, Pisidium and Chironomus plumosus) comprised 36% of the fauna, up considerably from the negligible percentage they formed at station 0125. Coarse detrital grazers (these graze on the organic matter itself or on the microfauna associated with it) comprised the majority of the benthic fauna (56%) and included all of the chironomids (except Chironomus and Procladius, the sole predator) as well as the crustaceans Gammarus fasciatus and Asellus, and the snail Amnicola limosa. Noteworthy was the presence of the chironomids Orthocladius and Potthastia, both of which are typical of more mesotrophic areas (Saether 1975, Soponis 1977). The low faunal density, and in particular the low oligochaete density, further indicated a relatively low level of organic enrichment.

Station 0140 was located near the eastern end of Trenton opposite a sewage treatment plant. Though sediment data were lacking for this station, the benthic fauna bore evidence of organic enrichment and density was the highest of any station at Trenton or Belleville. Sediment deposit feeders (oligochaetes) comprised 28% of this fauna, which, though lower than at station 0346, was much higher in terms of total density (Table 3.4.4). Grazers comprised 66% of the fauna and much of this was due to the very high density of Gammarus fasciatus, an epibenthic grazer feeding primarily on microorganisms associated with both detritus and living macrophytes. Similarly prolific were the chironomids Glyptotendipes and

Paratanytarsus, also grazers on detritus and algae. All of these could have been directly influenced by an increase in organic material (both coarse and fine particles) and in particular an increased density of sediment microorganisms.

Station 0156 was located off the eastern end of Trenton approximately 1.5 km east of Station 0140. Sediments were a sand-silt mix (61% : 32%) moderately high in organic content. The benthic community was noticeably sparse and consisted primarily of fine sediment feeders (38%) and a large predator population (48%). Grazers, such as G. fasciatus and Asellus comprised the remainder (14%). The high pesticide levels at this station may have had some effect on the total density, which, given the high organic content, seemed low in comparison to the other stations. In light of the high sand content, the levels of pesticides here seemed very high.

Station 0161, located along the north shore east of Trenton was also situated offshore from a sewage treatment plant. Sediments in this area were mainly sand and gravel (85%) low in both silts and organic content. As at station 0156, sediment fine particle feeders comprised 42% of the fauna while predators and grazers comprised 42% and 16% respectively. The benthic fauna at both of these stations seemed most affected by sediment type, which appeared to have limited the fine particle feeding component to a smaller fraction.

The remaining five stations were all located at Belleville (Fig. 3.4). Sediment analysis revealed that substrates were primarily silts in this area, very high in organic content. Levels of most contaminants were similarly high and most exceeded M.O.E. guidelines.

Station 0181 was located just east of the mouth of Belleville Harbour in an area of silty sediments, high in organic matter. The benthic fauna consisted primarily of sediment fine particle feeders (49%) such as the oligochaetes and Chironomus. Filterers (suspension feeders-Cheumatopsyche) and predators comprised 0.06% and 45% respectively. The higher sediment organic content had not resulted in an increase in the density of the oligochaetes and other fine particle feeders, as might have been expected under such circumstances. Among the contaminants tested for, a possible cause could have been the levels of hydrocarbons and PCBs (pesticides were below detection levels), both of which appear to readily affect the sediment feeding fauna, at least in standard bioassay tests (Mayer and Ellersieck 1986). This would of course have depended on the bioavailability of these compounds in the sediments.

Station 0182 was located along the north shore approximately 1 km east of station 0181. The benthic fauna was very reduced in density and diversity, and lacking were most of the sediment fine particle feeders such as the oligochaetes and the sphaeriid clams. Only the epibenthic grazers were present and while gravel/rock substrates could have readily accounted for this low density of organisms and especially of the burrowing fauna, the absence of sediment data makes this impossible to confirm.

Station 0192 was located further out into the bay, opposite station

0182. Sediments were mainly silts (60%), with some clay (14%) and sand (24%) and were high in organic content. The benthic fauna, despite the high organic content, was rather low in both density and biomass and averaged only 379 organisms/m2 (Table 3.4.3). Fine sediment feeders made up 52% of the fauna, of which the majority were oligochaetes and Chironomus plumosus. Predators (Cryptochironomus, Coelotanypus, and Procladius) also made up an unusually large percentage of the fauna (43%), while sediment grazers comprised the remaining 5%.

Station 0195, located 2 km east of station 0192, was situated in a similarly organic area, high in silt (64%) and organic content. Despite the high organic content, density of organisms was again relatively low. The sediment feeding fraction (oligochaetes, Pisidium and Chironomus) made up 50% of the fauna, while predators again made up an uncharacteristically large proportion of the fauna (45%). At both this station and the preceding one, contaminant levels (including the pesticides DMDT methoxyclor (515 ng/g at station 0192), endrin and endosulfan 11 (33 ng/g respectively at station 0195)) were higher than at any of the other stations and could have been a factor in the low density of organisms.

Station 0199, located in sandy sediments in a bay at the east end of Belleville, had a lower organic content and contaminant levels than any of the preceding stations. Despite the low organic content of the sediments, a sizeable benthic fauna existed at this station and in fact was larger than any of the stations in the siltier areas. The largest group (89%) was the sediment detrital grazers (Endochironomus and Gammarus fasciatus) usually associated with coarse organic debris. A small group of sediment feeders (10%) and predators (1%) comprised of the remainder of the benthos.

In summary, the stations along the Trenton waterfront indicated that organic content and sediment particle size were the major factors determining the composition of the benthic fauna. One station, 0140, gave evidence of organic enrichment, though much of this appeared to be coarse organic detritus. Contaminant levels were generally fairly low and did not appear to have an effect on the fauna. One exception may be station 0156 where pesticide levels were high and benthic density was reduced. The results obtained by Beak (1987) correlating high pesticide levels with reduced faunal diversity imply that these may also be affecting the density of organisms at this station.

Stations along the Belleville waterfront were for the most part unusually low in density of organisms, especially when levels of organic matter were considered. Sediment fine particle feeders, while still the major fraction, comprised less of the fauna than sediment organic content indicated should be the case. While some pesticide levels were high at stations 0192 and 0195, the only sediment contaminant levels that were unusually high at all stations were PCBs and solvent extractables and these may have contributed to the generally reduced fauna, especially of certain groups. PCBs, if present in an available form, were at high enough levels that they could have been toxic to amphipods (G. fasciatus) (Mayer and Ellersieck 1986), a group conspicuously reduced at those stations with the highest PCB levels, namely 0181, 0192, and 0195 (though this could also

have been due to reduced macrophyte levels (Crowder & Bristow 1986)).

<u>Summary</u>

1) Sediments, and sediment organisms, were generally characteristic of eutrophic conditions at both Trenton and Belleville. Only Station 0140, at Trenton, showed evidence of organic pollution.

2) Pesticide levels were high at station 0156 and may be responsible for some reduction in density of organisms.

3) Stations 0181, 0182, and 0195 at Belleville all had higher sediment contaminant levels, especially of PCBs and hydrocarbons. Despite a high sediment organic content, these stations had unusually low densities of organisms, especially the fine sediment (organic) feeding fraction.

4) Levels of some pesticides were higher at stations 0192 and 0195, and may also be responsible for some of the reduction in density at these stations.

5) Substrate type and organic content were the major determining factors at the other stations of both Trenton and Belleville.

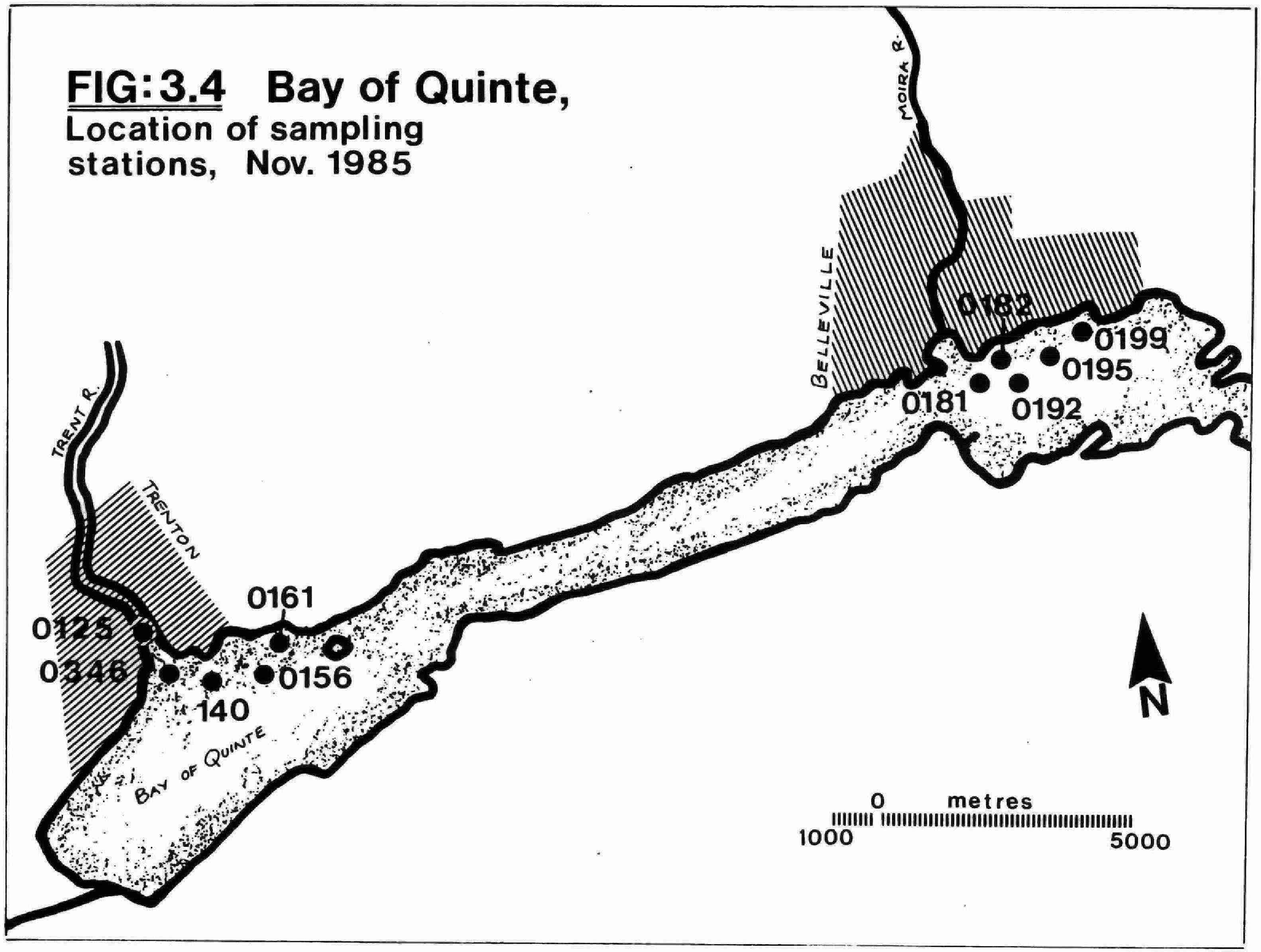

FIG: 3.4 Bay of Quinte,
Location of sampling stations, Nov. 1985

TABLE 3.4.1. WATER QUALITY DATA - BAY OF QUINTE. (TAKEN 1 M OFF BOTTOM).

Station Number	pH	Hardness (mg/l)	Chemical Oxygen Demand (COD) (mg/l)	Dissolved Organic Carbon (DOC) (mg/l)	Total Kjeldahl Nitrogen (TKN) (mg/l)	Turbidity	Suspended Particulate (mg/l)	Sodium (Na) (mg/l)	Chloride (Cl) (mg/l)
0125	8.34	110.5	16.4	5.6	0.44	3.10	5.39	4.27	7.60
0346	8.39	112.5	19.8	5.6	0.43	2.40	5.74	4.06	7.70
0140	8.22	114.5	17.1	5.7	0.47	1.96	6.75	4.86	8.50
0156	8.21	115.0	16.4	5.6	0.45	1.36	3.67	4.53	7.95
0161	8.26	125.5	16.9	5.6	0.55	1.96	26.83	5.82	10.15
0181	8.30	118.0	32.9	5.7	0.94	16.40	20.67	4.35	7.65
0182	8.11	115.0	22.4	7.5	0.59	1.14	3.05	7.64	12.75
0192	8.31	97.5	18.0	5.8	0.42	2.00	3.97	4.25	7.85
0195	8.36	119.0	21.8	6.2	0.53	6.40	24.11	4.64	8.40
0199	8.28	113.5	22.7	7.6	0.51	4.10	11.99	4.82	8.45

TABLE 3.4.2. SEDIMENT DATA - BAY OF QUINTE.

Station Number	Grain Size (%) Gravel/Sand/Silt/Clay	Total Organic Carbon (TOC) (mg/g)	Loss on Ignition (LOI) (%)	Total Phosphorus (TP) (mg/g)	Total Kjeldahl Nitrogen (TKN) (mg/g)	Solvent Extractables (ug/g)
0125	1/94/4/1	5.6	1.50	0.13	0.70	1,430.0
0346	1/76/18/4	14.0	5.60	0.84	0.20	468.0
0140	-	-	-	-	-	-
0156	0/61/32/4	64.0	14.00	1.39	0.30	3,476.0
0161	2/85/11/1	12.0	2.00	0.86	0.80	891.0
0181	0/29/57/13	120.0	22.00	1.55	2.50	6,163.0
0182	-	-	-	-	-	-
0192	0/25/60/14	140.0	26.00	1.52	1.70	6,870.0
0195	0/20/65/14	130.0	24.00	1.49	0.20	7,198.0
0199	7/82/9/2	20.0	20.00	0.90	0.10	448.0

Station Number	Cu (ug/g)	Cr (ug/g)	Hg (ug/g)	Fe (ug/g)	As (ug/g)	Zn (ug/g)	Al (ug/g)	Total PCB's (ug/kg)
0125	13.0	200.0	< 0.01	16,000.0	6.48	440.0	1,600.0	< 20
0346	18.0	21.0	0.05	9,000.0	1.00	80.0	6,500.0	70
0140	-	-	-	-	-	-	-	-
0156	34.0	50.0	0.20	16,000.0	2.54	120.0	11,000.0	115
0161	8.6	20.0	0.07	4,200.0	1.20	44.0	2,100.0	-
0181	62.0	71.0	0.50	25,000.0	16.00	230.0	19,000.0	320
0182	-	-	-	-	-	-	-	-
0192	68.0	83.0	0.56	28,000.0	14.00	270.0	21,000.0	265
0195	94.0	76.0	0.73	26,000.0	24.70	340.0	20,000.0	170
0199	10.0	18.0	0.05	5,800.0	4.34	48.0	2,400.0	45

TABLE 3.4.3. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA - BAY OF QUINTE.

All values are expressed as #'s per square meter.

	Station #0125		Station #0346		Station #0140	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera			5	0.0038		
O. Plecoptera						
O. Odonata					5	
O. Trichoptera	14	0.0016			78	0.1519
O. Coleoptera	1					
O. Diptera						
F. Chironomidae	340	1.0092	449	1.3956	1,288	0.5960
F. Chaoboridae						
F. Ceratopogonidae						
Class Arachnida						
O. Acarina			3			
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	45	0.0453	56	0.4527	784	0.2028
O. Isopoda	3		13	0.1762	41	0.0997
MOLLUSCA						
Class Gastropoda	22	0.2348	3	0.0306	60	0.0827
Class Pelecypoda	4	0.0207	23	0.0398	4	0.0095
(+large clam)				(1215.3)		
NEMATODA						
PLATYHELMINTHES						
Class Turbellaria	1		5	0.0069	11	0.0071
ANNELIDA						
Class Hirudinea			5	0.0414		
Class Oligochaeta	11	0.0008	299	0.2804	456	0.0096
TOTAL # ORGANISMS	441		861		2,727	
TOTAL BIOMASS		1.3124		2.4274 (1217.73)		1.1593
CORRECTED BIOMASS (+10%)		1.4436		2.6701 (1339.5)		1.2752

TABLE 3.4.3. (Continued)

All values are expressed as #'s per square meter.

	Station #0156		Station #0161		Station #0181	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera						
O. Plecoptera						
O. Odonata						
O. Trichoptera	1	0.0006			5	
O. Coleoptera						
O. Diptera						
F. Chironomidae	174	0.6609	287	0.1843	165	0.2328
F. Chaoboridae	1				6	0.0017
F. Ceratopogonidae	1				3	0.0106
Class Arachnida						
O. Acarina	6	0.0055	29	0.0125	78	0.0536
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	18	0.0737	36	0.0263		
O. Isopoda	1		5	0.0020		
MOLLUSCA						
Class Gastropoda	13	0.2836	22	0.1694		
Class Pelecypoda	17	0.0182			61	0.1325
NEMATODA	1	0.0006	5	0.0023		
PLATYHELMINTHES						
Class Turbellaria						
ANNELIDA						
Class Hirudinea						
Class Oligochaeta	147	0.2428	165	0.0483	87	0.0255
TOTAL # ORGANISMS	380		549		405	
TOTAL BIOMASS		1.2859		0.4451		0.4567
CORRECTED BIOMASS (+10%)		1.4145		0.4896		0.5024

TABLE 3.4.3. (Continued)

All values are expressed as #'s per square meter.

Station #0182		Station #0192		Station #0195		Station #0199	
Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
6	0.0099						
				1		15	0.0184
24	0.0176	208	0.4457	269	0.6716	460	1.1911
		1		1			
				1			
		10	0.0045	23	0.0132		
19		3	0.0074	8	0.0275	296	0.1669
5						5	
						10	1.0708
		17	0.0073	19	0.0175		
						5	0.0490
3		140	0.0537	259	0.1994	41	0.0050
57		379		581		832	
	0.0275		0.5843		0.9292		2.5012
	0.0303		0.6427		1.0221		2.7513

TABLE 3.4.4. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - BAY OF QUINTE.

	STATION NUMBER (#/m²)									
SPECIES	0125	0346	0140	0156	0161	0181	0182	0192	0195	0199
TRICHOPTERA										
Hydropsychidae:										
Cheumatopsyche sp.	19					15				
Leptoceridae: Nectopsyche sp.			8							
Polycentropodidae:										
Polycentropus sp.	15		31				11			
COLEOPTERA										
Elmidae:										
Stenelmis sp.	4									
Dubiraphia sp.									4	31
ODONATA										
Coenagrionidae: Ishnura sp.			15							
DIPTERA										
Chironomidae:										
Cryptochironomus sp.	8			4	38			15	15	
Chironomus semireductus grp								19		
Chironomus plumosus grp		23		11		11			31	
Endochironomus sp.	65	276	138							31
Demicryptochironomus sp.								8		
Glyptotendipes sp.	310	8	666		15		15			260
Cladotanytarsus sp.	23									
Paratanytarsus sp.			329		15					15
Rheotanytarsus sp.							8			
Orthocladius sp.		31	46		8					15
Psectrocladius psilopterus grp							8			
Stenochironomus sp.										15
Potthastia sp.		15								
Coelotanypus sp.				15				27	34	
Thienemannimyia complex	8					19				
Procladius sp.	23	46	176	184	169	92		84	272	15
Chaoboridae:										
Chaoborus punctipennis				4		15		4	4	
Ceratopogonidae:										
Palpomyia complex				4					4	
AMPHIPODA										
Gammaridae:										
Gammarus fasciatus	42	31	1,187	15	38		57		8	414
ISOPODA										
Asellidae: Asellus sp.	8	8	46	4			15			15
GASTROPODA										
Hydrobiidae: Amnicola limosa	11	8	31	23	8					
Planorbidae: Helisoma sp.			69		8					
PELECYPODA										
Sphaeriidae:										
Pisidium sp.			8	4					8	
P. fallax									19	
P. ventricosum						15				
P. casertanum		23						15		
Sphaerium sp.				15						
OLIGOCHAETA										
Tubificidae:										
Tubifex tubifex					8			11	11	
Spirosperma ferox								15		
Quistadrilus multisetosus	4	31		8					34	
Isochaetides freyi							4			
Limnodrilus hoffmeisteri		15	314	34		8		27	38	
Immatures with capilliform setae				15	61	11		15		
Immatures without capilliform setae	15	145	758	15	77	46	4	46	119	92
Naididae:										
Dero sp.				38	54	8		4	54	
Enchytraeidae: sp. indet.	4				8				11	
Total Number of Organisms	559	660	3,822	393	497	240	122	290	716	888
Species Diversity (H')	2.46	2.71	2.90	2.88	2.98	2.77	2.40	3.21	2.94	2.20
Species Richness (S.R.)	2.81	2.33	2.17	3.24	2.46	2.17	2.02	2.77	2.87	1.65
Evenness (J')	0.63	0.73	0.72	0.72	0.80	0.83	0.80	0.87	0.73	0.66

4. NIAGARA RIVER

Introduction

The Niagara River, in the region of Niagara Falls, N.Y., has been identified as receiving a variety of contaminants that are leaching into some of its tributary streams from waste disposal sites. Many of these are among the more toxic chemicals, such as PCBs, Mirex and a large variety of other organic compounds (I.J.C. 1987). All of these have also been found in sediments in the river.

Water Quality

The Niagara River was characterized as hard water, of high pH, and low in organic matter. The river was moderately turbid, with the turbidity and suspended particle load (Table 4.1) increasing with increasing water velocity.

Sediment Quality

Sediments varied from predominantly silts at the Lake Erie end of the river to rocky substrates in some of the narrowed regions (Table 4.2). Two stations remained unsampled due to a lack of suitable substrates.

Station 0113 was located in Lake Erie off the Buffalo, New York (Fig. 4.1) waterfront, close to the entrance to the Niagara River. The substrate was mainly silts (75%) and both organic content and contaminant levels were moderately high. Of the 8 parameters in Table 4.2 for which guidelines were available, levels of 7 were higher, with levels of PCBs exceeding the guideline by the greatest amount (6.5 times). Sigg et al. (1987) found that organic matter in the water column was the major precipitant of heavy metals, since these compounds appeared to have the greatest sorptive capacity. Thus, the metals and other contaminants in the Niagara River were most likely to accumulate in sediments where organic matter had also accumulated (Mudroch & Duncan 1986).

Station 0127 was located in the Niagara River south of Grand Island (Fig. 4.1). Though sediment data were lacking, the benthic community composition indicated this was an area of hard substrate.

Station 0145 was located in the Tonawanda Channel near the confluence of Tonawanda Creek. Sediments were primarily silt (51%) and sand (30%) (Table 4.2) and organic content of the sediments was moderately high. Though levels of all contaminants exceeded the guidelines, levels of PCB's, Zn, and solvent extractables were the highest of any station in the river, exceeding the allowable limits by 4.5, 4 and 5 times respectively (the I.J.C. has identified this section of the river as one of the areas where contaminants have accumulated to greatest concentrations (I.J.C. 1987)).

Stations 0183 and 0154 were located close together in the Tonawanda Channel. Though sediment data were lacking, the benthic community indicated these were areas of hard substrates. Both stations were located

on the outer curve of the channel, normally a highly erosional area of fluvial environments.

Station 0158 was located just east of Niagara Falls, New York, along the north bank of the river (Fig. 4.1). Sediments were primarily sand and gravel (83% and 7%), low in silt (7%) and organic content. Contaminant levels, reflecting the low organic content, were low as well and only PCBs exceeded the guidelines (by a small amount (Table 4.2)).

Station 0155 was located approximately 2 km downstream from station 0158, also in a sandy (74%) area. Silt content in these sediments was higher than at station 0158 (22% here versus 7% at station 0158), and organic content was higher as well (Table 4.2). Concurrent with the higher silt content, contaminant levels were also elevated and most exceeded M.O.E. guidelines, though PCBs were the only ones that were significantly higher.

Station 0177 was located at the eastern end of Niagara Falls, N.Y., approximately 1 km west of station 0155. Sediments were almost entirely sand (89%) and gravel (4%) with a small amount of organic matter (Table 4.2). Contaminant levels were low, except for PCB's which exceeded M.O.E. guidelines. While PCBs were ca. 3.5 times higher than the guidelines, this result is considered to be significant in light of the high sand content.

Benthic Invertebrates

Benthic environments in the river ranged from primarily soft silty sediments at the Lake Erie outflow, to sand and rock in the main river channel where flow was high.

Station 0113 was located in Lake Erie off the Buffalo, New York (Fig. 4.1) waterfront, close to the entrance to the Niagara River. The benthic community was typical of depositional areas comprised of fine sediments (Table 4.4). Not surprisingly, oligochaetes dominated the benthic community and fine particle feeders as a whole comprised 94% of the total fauna. The remainder was comprised of predators (5.5%), while filterers (Hydropsyche) made up a mere 0.5%. The oligochaete fauna that was present was typical of organically enriched areas and was dominated by the Limnodrilus species that are usually the major components in eutrophic areas.

Station 0127 was located in the Niagara River (Fig. 4.1) and, though sediment data were lacking, appeared to be in an area of hard substrate. Benthic burrowing species were entirely lacking and the largest fraction of the fauna was the filterers. The extremely reduced fauna was likely a result of the hard substrate and the reduced sampling efficiency of soft sediment sampling devices in such areas. It is possible, therefore, that the actual densities of organisms were higher than reported and the low numbers were simply a sampling artifact.

Station 0145 was located in the Tonawanda Channel near the confluence of Tonawanda Creek. Sediments were primarily silt (51%) and sand (30%) and

organic content was moderately high, as were most contaminant levels (especially PCB's and solvent extractables). Despite the organic content, density of the fauna, especially of the sediment feeding component, was low. The sediment fine particle feeders comprised 58% of the fauna and oligochaetes alone constituted 51% of the organisms present. Epibenthic grazers such as Gammarus fasciatus and Asellus comprised 36% of the fauna while the predators comprised the rest. Compared to station 0113, the density of organisms was much lower at station 0145, despite a higher organic content. PCB's and solvent extractables were both high, as noted earlier, and could have been a factor in this reduced fauna since PCB's have been shown, at least in solution, to be toxic at levels below those recorded here (Meyer and Ellersieck 1986). Levels of some pesticides were higher than at the other stations (dieldrin (35 ng/g), DMDT methoxyclor (190 ng/g), and heptachlor epoxide (28 ng/g) were the highest though chlordanes and endosulfans were also present) and these could also have contributed to the reduction in the benthic community.

Stations 0183 and 0154, located close together in the Tonawanda Channel, were very similar in faunal composition. Though sediment data were lacking, both stations were located on the outer curve of the channel, normally a highly erosional area of fluvial environments. The benthic fauna was typical of hard substrates in flowing waters and consisted primarily of the filterers Cheumatopsyche and Hydropsyche. These comprised 76% of the fauna at station 0183 and 71% at station 0154. Epibenthic grazers on detritus (G. fasciatus) or algae (Goniobasis livescens) made up most of the remainder. All are strongly rheophilic and would have thrived only in areas of strong current. The absence of sediment feeders therefore was concluded to be due to substrate type.

Station 0158 was located just east of Niagara Falls, New York, along the north bank of the river (Fig. 4.1). Sediments were primarily sand and gravel (83% and 7%), low in silt (7%) and organic content. Contaminant levels, reflecting the low organic content, were low as well (Table 4.4). Fine sediment feeders formed only a very small part of the fauna, the current and lack of fine sediment limiting their density to 1.5% of the fauna. Filterers (Hydropsyche) were prevalent (8%) but the greatest fraction was formed by the detrital and algal grazers which comprised 90.5%. Algal grazers such as Paratanytarsus and Agraylea formed the largest single feeding group (54%) and both are generally most common on hard substrate in areas of pronounced current (Oliver & Roussel 1983; Wiggins 1977). Grazers on and in course detritus, represented by Endochironomus, were the other dominant group and comprised 23% of the fauna just from this species alone (Table 4.2). To this were added other detrital grazers such as Mystacides, G. fasciatus, and the snail species. Finally, predators (Oecetis, Nyctiophylax, Enallagma, and Procladius) comprised 3% of the fauna. The fauna, overall, appeared to be a normal river community whose character was determined primarily by the current (most of the species were rheophilic to some degree). Species composition and density was determined by the available food resources, namely algae and coarse detritus.

Station 0155 was located approximately 2 km downstream from station

0158, also in a sandy (74%) area. Silt content in these sediments was higher than at Station 0158 (22% here versus 7% at Station 0158), and organic content was higher as well (Table 4.4). Concurrent with the higher silt content, contaminant levels were also elevated, and most exceeded M.O.E. guidelines, though PCBs were the only ones significantly higher. Benthic community diversity was high as were the density and biomass (Tables 4.1 and 4.2). Fine sediment feeders such as the oligochaetes made up proportionately more of the fauna (16%), also a result of the increased organic content of the sediment. Algal grazers such as Agraylea and Paratanytarsus still made up the largest fraction (48%) indicating attached algae played a major role. As at station 0158 detrital grazers made up most of the rest of the fauna (33%), the most common of which was Endochironomus, a feeder on coarse detritus and decaying vegetation. Predators comprised the remaining 3% of the fauna. Again substrate appeared to be the main determining factor affecting both species composition and density of organisms. Though some pesticide levels were high at this station (hexachlorocyclohexanes) these were not among the compounds that correlated well with decreased density of invertebrates (Beak 1987).

Station 0177 was located at the eastern end of Niagara Falls, N.Y., approximately 1 km west of station 0155. Sediments were almost entirely sand (89%) and gravel (4%) with a small amount of organic matter (Table 4.4). Contaminant levels were low except for PCB's, which exceeded M.O.E. guidelines. The fine sediment feeding component (mainly oligochaetes) was again low (18%) and was dominated by the oligochaete Quistadrilus multisetosus, a common species in sandy areas. Filterers (Cheumatopsyche and Hydropsyche) formed one major faunal group, comprising 26% of the benthic organisms, while detrital grazers (25%) such as G. fasciatus and A. limosa, and algal grazers (Paratanytarsus and Ferrissia paralella) comprised the others (25%). Predators (Nyctiophylax) comprised 3.5% of the fauna.

Both stations 0158 and 0177 were located downstream from some of the major contaminant sources on the Niagara River which yearly contribute a variety of chemicals to its waters (I.J.C. 1987). Aside from elevated levels of PCBs (pesticides and other organics were generally very low at most stations), no effects of contaminants could be determined either in the sediments or on the community structure of the benthos.

In summary, the only area that appeared to be suffering from any adverse effects was station 0145. The high organic content of the sediments did not support as high a density of sediment fine particle feeders (oligochaetes) as could be expected (as occurred for example at station 0113, which had a similar substrate type). Most contaminant levels were higher at this location, but PCB's, solvent extractables, and pesticides were disproportionately so.

Downstream the benthic fauna appeared diverse and density was high at all stations. The controlling factors in all cases seemed to be the substrate type and related to this, the current velocity, both of which have favoured the development of a large population of algal feeders and

coarse detrital grazers. Fine sediment feeders formed only a small part of the fauna at these stations.

Station 0113 appeared similar to nearshore areas of Lake Ontario (Section 3) and was characterized by an accumulation of fine sediments of high organic levels. A large oligochaete fauna, predominantly Limnodrilus spp. made up most of the density and biomass.

Summary

1) Areas in the Niagara River were mainly erosional and were characterized by sand and gravel substrates. The fauna in these areas was typical of fluvial areas and consisted primarily of epibenthic, rheophilic species. Density, diversity, and biomass were generally high.

2) Contaminant levels were low in most areas and reflected the sandy substrate. As pointed out by Mudroch and Duncan (1986) these areas tend to accumulate the least amount of contaminant materials due to a lack of organic matter.

3) Station 0145, in a depositional area, had high levels of certain contaminants. Benthic density and diversity were low, despite high sediment organic levels. While these organic levels may have reflected high solvent extractable levels, these areas should have been able to support a larger community.

4) Sediments in Lake Erie at Buffalo, New York (Station 0113) also had high organic levels and supported a large density of benthic invertebrates. Comprised of the fine particle feeders, this area appeared somewhat polluted by organic matter.

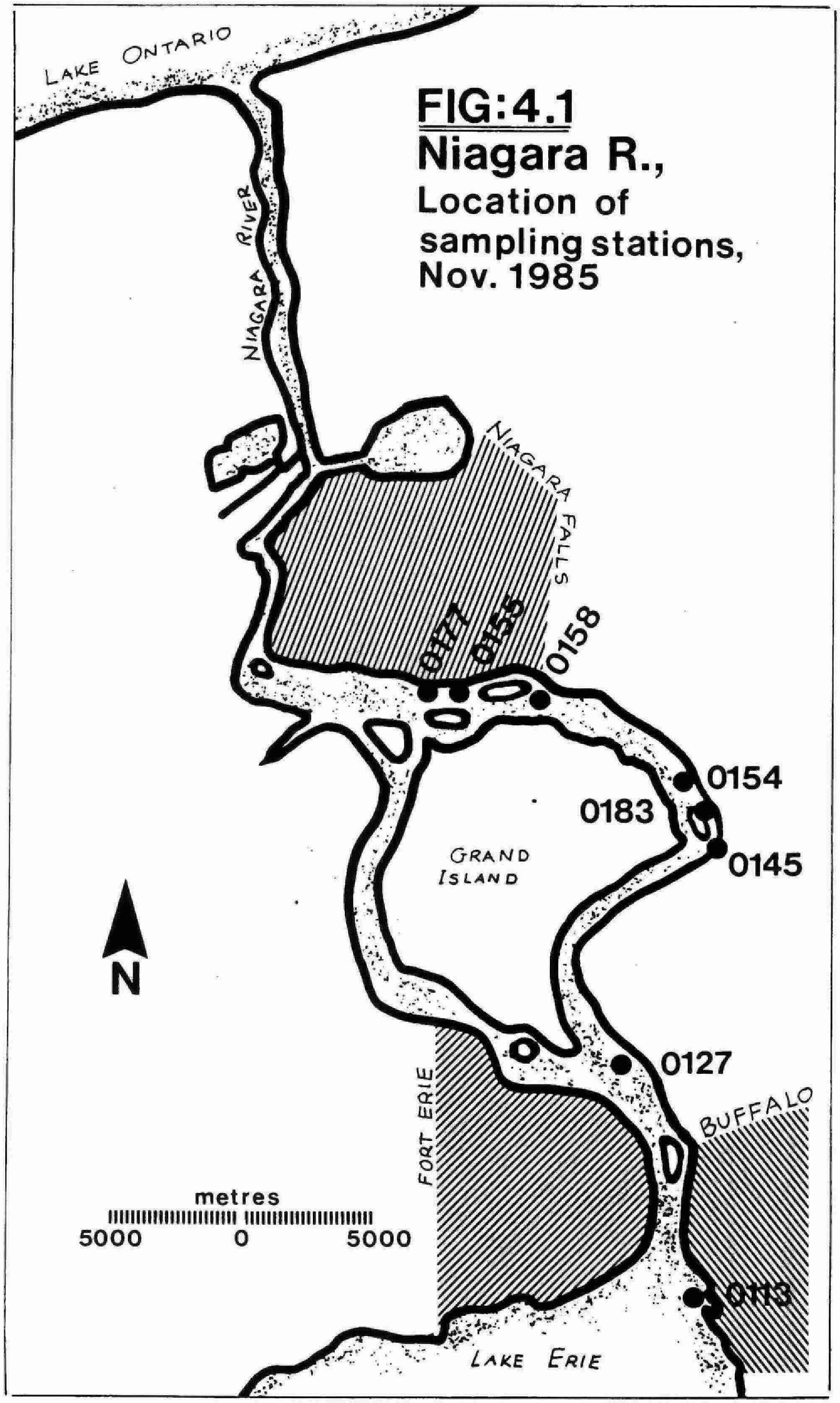

FIG:4.1
Niagara R.,
Location of sampling stations, Nov. 1985

TABLE 4.1. WATER QUALITY DATA - NIAGARA RIVER. (TAKEN 1 M OFF BOTTOM).

Station Number	pH	Hardness (mg/l)	Chemical Oxygen Demand (COD) (mg/l)	Dissolved Organic Carbon (DOC) (mg/l)	Total Kjeldahl Nitrogen (TKN) (mg/l)	Turbidity	Suspended Particulate (mg/l)	Sodium (Na) (mg/l)	Chloride (Cl) (mg/l)
0113	8.21	126.0	12.9	4.0	0.410	14.10	16.15	11.90	19.05
0127	8.23	122.5	10.0	2.1	0.360	26.00	48.46	9.14	15.55
0145	8.25	123.5	9.5	2.3	0.300	14.80	21.16	9.33	16.90
0183	8.24	123.0	6.7	2.2	0.290	12.90	24.35	9.22	16.55
0154	8.28	121.5	20.4	2.2	0.290	11.30	26.01	9.23	16.65
0158	8.22	135.5	9.1	2.8	0.390	15.20	19.96	10.50	18.90
0155	8.30	139.0	9.3	3.0	0.390 AUL	18.40	23.76	11.10	19.50
0177	8.23	129.0	9.5	2.4	0.330 AUL	16.70	31.16	9.88	17.65

TABLE 4.2. SEDIMENT DATA - NIAGARA RIVER.

Station Number	Grain Size (%) Gravel/Sand/Silt/Clay	Total Organic Carbon (TOC) (mg/g)	Loss on Ignition (LOI) (%)	Total Phosphorus (TP) (mg/g)	Total Kjeldahl Nitrogen (TKN) (mg/g)	Solvent Extractables (ug/g)
0113	0/7/76/19	25.0	5.4	1.10	0.7	2,480.0
0127	-	-	-	-	-	-
0145	3/30/51/14	46.0	7.6	1.33	3.9	8,093.0
0183	-	-	-	-	-	-
0154	-	-	-	-	-	-
0158	8/83/7/2	< 5.0	0.9	0.44	2.5	349.0
0155	0/74/22/2	29.0	2.8	0.85	1.5	2,485.0
0177	4/89/6/1	5.4	0.5	0.42	5.1	270.0

Station Number	Cu (ug/g)	Cr (ug/g)	Hg (ug/g)	Fe (ug/g)	As (ug/g)	Zn (ug/g)	Al (ug/g)	Total PCB's (ug/kg)
0113	62.0	46.0	0.40	30,000.0	12.70	220.0	16,000.0	325
0127	-	-	-	-	-	-	-	-
0145	86.0	48.0	0.51	24,000.0	7.47	400.0	14,000.0	445
0183	-	-	-	-	-	-	-	-
0154	-	-	-	-	-	-	-	-
0158	8.7	19.0	0.49	6,900.0	2.00	93.0	2,300.0	55
0155	36.0	44.0	2.00	13,000.0	3.61	310.0	5,800.0	395
0177	16.0	23.0	0.10	12,000.0	2.14	120.0	3,600.0	185

TABLE 4.3. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA - NIAGARA RIVER.

All values are expressed as #'s per square meter.

	Station #0113		Station #0127		Station #0145	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera						
O. Odonata						
O. Trichoptera	41	0.0826	13	0.0314		
O. Diptera						
F. Chironomidae	195	0.2229	2		70	0.0343
F. Empididae	1					
Class Arachnida						
O. Acarina						
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda			2	0.0032	42	0.0094
O. Isopoda					46	
O. Decapoda						
MOLLUSCA						
Class Gastropoda	22	0.4809	5	0.0187	47	1.6947
Class Pelecypoda	103	0.3580			3	0.0123
COELENTERATA			192			
PLATYHELMINTHES						
Class Turbellaria			21	0.0093		
ANNELIDA						
Class Hirudinea	3	0.0054				
Class Oligochaeta	4,050	5.8232			615	0.4655
TOTAL # ORGANISMS	4,415		222		823	
TOTAL BIOMASS		6.9730		0.0626		2.2162
CORRECTED BIOMASS (+10%)		7.6703		0.0689		2.4378

TABLE 4.3: (Continued)

All values are expressed as #'s per square meter.

	Station #0183		Station #0154		Station #0158	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera					8	
O. Odonata					14	0.0039
O. Trichoptera	392	0.2926	523	1.034	1,154	0.4870
O. Diptera						
F. Chironomidae			1	0.0004	9,058	3.1686
F. Empididae	3					
Class Arachnida						
O. Acarina					41	0.0099
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	11	0.0705	11	0.0071	476	1.4551
O. Isopoda						
O. Decapoda					5	17.4219
MOLLUSCA						
Class Gastropoda	106	0.9076	78	1.454	148	2.4330
Class Pelecypoda					15	
COELENTERATA	65	0.0077				
PLATYHELMINTHES						
Class Turbellaria	98	0.0319			218	0.1534
ANNELIDA						
Class Hirudinea						
Class Oligochaeta			1		91	0.0244
TOTAL # ORGANISMS	675		614		11,246	
TOTAL BIOMASS		1.3104		2.4955		25.1572
CORRECTED BIOMASS (+10%)		1.4414		2.7451		27.6729

TABLE 4.3. (Continued)

All values are expressed as #'s per square meter.

Station #0155		Station #0177	
Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
265	0.0658	228	0.0113
3,912	1.5932	165	0.0102
		5	
5			
66	0.1172	77	0.0349
5			
725	9.9779	248	0.6814
5	0.0007	33	0.0410
56	0.0291	13	0.0017
15	0.0314		
628	0.2635	204	0.5967
5,682		973	
	12.0788		1.3772
	13.2867		1.5149

TABLE 4.4. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - NIAGARA RIVER.

SPECIES	STATION NUMBER (#/m²)							
	0113	0127	0145	0183	0154	0158	0155	0177
EPHEMEROPTERA:								
Caenidae: Caenis sp.						23		
ODONATA								
Coenagrionidae: Enallagma sp.						23		
TRICHOPTERA								
Hydropsychidae:								
Cheumatopsyche sp.		13		529	272	919		92
Hydropsyche sp.	15			306	184		46	506
Hydroptilidae: Agraylea sp.						758	306	
Leptoceridae:								
Oecetis sp.						92		
Mystacides sepulchralis						23		
Polycentropodidae: Nyctiophylax sp.						115		77
DIPTERA								
Empididae: sp. indet.				8				15
Chironomidae:								
Cryptochironomus sp.			15				77	
Chironomus plumosus group	4		46					
Paratanytarsus sp.						5,171	3,217	429
Rheotanytarsus sp.		2						
Endochironomus sp.						2,482	1,440	
Procladius sp.	188		15			92	46	
Orthocladius sp.							15	
Dicrotendipes sp.						414	322	
AMPHIPODA								
Gammaridae: Gammarus fasciatus		2	107	15	27	483	123	184
ISOPODA								
Asellidae: Asellus sp.			138				15	
GASTROPODA								
Hydrobiidae: Amnicola limosa	4		15			92	460	352
Ancylidae: Ferrissia paralella								168
Physidae: Physella gyrina sayi				8	19	23		46
Valvatidae:								
Valvata sincera	15					23	107	
V. tricarinata							276	
Pleuroceridae:								
Goniobasis livescens				230	130			
Pleurocera acuta		5						
Lymnaeidae: Lymnaea stagnalis					4			
Planorbidae: Gyralus parvus				8				
PELECYPODA								
Sphaeriidae:								
Pisidium casertanum	77							77
P. henslowanum						46		
P. walkeri	65							
Musculium transversum	27							
HIRUDINEA								
Helobdella stagnalis	4							
Mooreobdella sp.							31	
OLIGOCHAETA								
Enchytraeidae: sp. indet.			31					
Tubificidae:								
Quistadrilus multisetosus	138		31					276
Limnodrilus hoffmeisteri	1,057						92	
L. claparedianus	138							
Potamothrix moldaviensis							31	
Immatures with capilliform setae	138							
Immatures without capilliform setae	1,716		291		4	69	659	61
Naididae: Dero sp.						46		
Total Number of Organisms	3,586	22	689	1,104	640	10,894	7,294	2,283
Species Diversity (H')	2.17	1.49	2.43	1.73	1.94	2.39	2.68	3.11
Species Richness (S.R.)	1.90	1.17	1.54	1.06	1.17	2.14	2.25	1.72
Evenness (J')	0.57	0.74	0.76	0.61	0.69	0.57	0.64	0.86

5 ST. CLAIR RIVER

5.1 ST. CLAIR RIVER - 1985

Introduction

The St. Clair River, and to the south the Detroit River together form the major navigational link between the upper and lower Great Lakes. In the area of Sarnia, the river has received effluent from a number of domestic and industrial sites, formost of which are the chemical industries located at the souhthern end of the city. Many of these have discharged toxic organic chemicals into the river (I.J.C. 1987). As recently as 1985, spills of chemicals have occured in the river which have ultimately found their way into the sediments.

Water Quality

Water quality data (Table 5.1) revealed the St. Clair River as a moderately hard water river of high pH and low in organic matter. While generally clear and low in suspended particles, it was in places moderately turbid. Salts (Na and Cl) were low throughout the system.

Sediment Quality

Sediments in the St. Clair River were generally sand with a consistently very low silt and organic content. In fact, silt content did not exceed 16% at any of the stations in the river (Table 5.2). Contaminant levels were also very low, and only in rare circumstances did these exceed M.O.E. guidelines.

While sediment data were lacking for station 0067, the benthic community composition indicated this was an area of hard substrates. Located in Lake Huron near the entrance to the St. Clair River, this area would likely have been subject to considerable erosional forces.

Station 0069, located in Sarnia at the entrance to Sarnia Bay, was in an area of predominantly sand substrate (85%). Silt level and organic content were relatively low, as were levels of most contaminants. Levels of solvent extractables and PCB's were high, however, with the latter exceeding guidelines by over 4 times (Table 5.2).

Station 0110 was located along the Sarnia waterfront in a similarly sandy substrate (82% sand) low in organic content. Consistent with such sandy areas, contaminant levels (including solvent extractables and PCBs) were low (Table 5.2).

Station 0020 was located at the south end of Sarnia just upstream from the main industrial complex south of the city (Fig. 5.1). Sediments were mainly sand and gravel, similar to stations 0069 and 0110, with a low (10%) silt content (this sampling station, as well as all the remaining downstream stations, was located along the east bank of the river, outside the main navigational channel). Organic content and contaminant levels

were low and only Cu slightly exceeded the levels set by M.O.E.

Sediment data were lacking for station 0024, located just south of the main industrial complex at the southern edge of Sarnia. Benthic sample residues (i.e., after field-washing) were mainly gravel with clumps of clay and a small amount of silt. Sample residues also contained a black tarry substance, presumed to be related to the perchloroethylene spill that occurred in this region during the summer of 1985.

Station 0066 was located at the north end of Stag Island in a predominantly sand-gravel area (98%) very low in organic content (Table 5.4) and thus low in contaminant levels as well.

Located at the south end of Stag Island, station 0064 was situated in a somewhat different substrate type. Though still mainly sand, silt formed a larger part of the substrate with a resultant increase in the organic content of the sediments. Contaminant levels, though higher than at station 0066, were low and still well below the guidelines for all parameters.

Much further downstream, station 0111 was located in an area of mainly sand and gravel substrates. Silt content and hence the organic levels, were low, while clay content was moderately high. Contaminant levels were low and none exceeded M.O.E. guidelines.

Station 0068, located at the southern tip of Fawn Island was situated in a sandy area (91%) very low in organic matter and contaminant levels.

Sediments at Station 0034, located just north of the confluence of the Chenel Ecarte, contained a relatively greater amount of silt and hence organic content was higher. The modest increase in organic content paralleled a similarly modest increase in contaminant levels, though all were low.

Benthic Invertebrates

The benthic communities of the river were generally defined as a function of the predominantly sandy substrates. Filterers, grazers and other epibenthic forms consistently comprised the greatest part of the community at each station, while the sediment infauna was reduced or absent at all stations.

Located in Lake Huron (Fig. 5.1) near the outflow to the St. Clair River, station 0067 yielded a fauna typical of lacustrine environments. While sediment data were lacking, the benthic community composition indicated this was an area of hard substrates, overlaid by coarse organic matter (Table 5.2). Sediment burrowers and fine particle feeders, such as the oligochaetes and sphaeriid clams, were virtually absent. Grazers on coarse detrital matter, such as Gammarus fasciatus, Baetisca lacustris, Mystacides sepulchralis, and a few other species, made up 91% of the fauna. Of these, the amphipods made up 90% of the fauna though only 7% of the biomass. The other major group was the algal grazers, represented by

Goniobasis livescens, which comprised 5.5% of the fauna. A small group of sediment grazers comprised the remainder.

Station 0069, located in Sarnia at the entrance to Sarnia Bay, was in an area of predominantly sand substrate (85%). Silt level and organic content were relatively low. Benthic faunal density was also low and consisted mainly of sediment fine particle feeders (55%), detrital grazers (9.5%), and predators (17%). The density, however, compared well with stations downstream (0110 and 0020) in areas of similar substrates (Table 5.4), and the higher levels of PCBs and solvent extractables (levels of which, considering the high sand content were quite high) appear to have had little effect on the community.

Station 0110 was located along the Sarnia waterfront in a similarly sandy substrate (82% sand) low in organic content. Consistent with such sandy areas, contaminant levels (including solvent extractables and PCBs) were low (Table 5.2). A more diverse benthic fauna was found in this area, of which oligochaetes and other fine sediment feeders formed only a relatively small amount (35%). Detrital grazers on coarse plant material and on living plants, such as Amnicola limosa, the amphipod and isopod species, as well as a number of the chironomid species, made up 56% of the total. Predators, such as Procladius and Cryptochironomus, comprised the rest. Apparently organic matter, which existed mainly as coarse detritus, determined the nature of the benthic community.

Station 0020 was located at the south end of Sarnia just upstream from the main industrial complex south of the city (Fig. 5.1). Sediments were mainly sand and gravel, similar to stations 0069 and 0110, with a low (10%) silt content and contaminant levels. The benthic fauna appeared to be primarily determined by sediment and flow characteristics. The largest percentage of the community was comprised of filterers (Hydropsyche spp.) which made up 59%, while fine sediment feeders, the oligochaetes and clams, comprised 28%, reflecting the low sediment organic content. Detrital grazers and predators comprised the remainder (9.5% and 3.5% respectively).

Sediment data were lacking for Station 0024, located just south of the main industrial complex at the southern edge of Sarnia. Benthic sample residues (i.e., after field-washing) were mainly gravel with clumps of clay and a small amount of silt. Sample residues also contained a black tarry substance, presumed to be related to the perchloroethylene spill that occurred in this region during the summer of 1985. Benthic diversity and density were extremely low, likely as a result of both substrate and chemical factors. The fauna was represented by only three species of organisms, the filterers (Cheumatopsyche) and two species of algal grazers (Goniobasis livescens and Ferrissia parallela), and these were present in extremely low densities. No sediment or detrital grazers were present, though samples did contain coarse organic debris. It would appear that the rock/gravel surfaces were the only suitable habitats remaining in this area since the three species present were associated more with the overlying water column than with the sediments, especially the finer, or organic parts.

Station 0066 was located at the north end of Stag Island in a predominantly sand-gravel area (98%) very low in organic content (Table 5.4) and thus low in contaminant levels as well. Benthic diversity and density was extremely low in this area as well and the benthos consisted of only four insect species. These were either coarse detrital grazers, such as Ceraclea, or filterers and predators (Hydropsyche and Isogenoides respectively). Sample residues for this station all consisted of coarse sand and of large pebble gravel, scoured clean of any algal growth. The area therefore seemed to be highly erosional and subject to much bottom movement. Such an unstable environment would be difficult for most organisms to invade and become established in.

Located at the south end of Stag Island, station 0064 was situated in a somewhat different substrate type. Though still mainly sand, silt formed a larger part of the substrate, with a resultant increase in the organic content of the sediments as well. Density of organisms was very high in this area and was dominated by grazers. Many of these, such as Endochironomus, Gammarus fasciatus, Polypedilum, and Amnicola limosa are also strongly associated with aquatic macrophytes, which were present in the sample residues. In total, this group made up 84% of the fauna. By comparison, sediment fine particle feeders comprised a mere 1.5% while predators (Nyctiophylax and Procladius) made up an additional 2.5%. Filterers (Hydropsyche) comprised the remaining 10% (Table 5.4). Coarse organic matter and macrophytes appeared to be the main factors determining the composition and density of the benthic fauna. The occurrence of macrophytes was in turn determined by depth and sediment type.

Much further downstream, station 0111 was located in an area of mainly sand and gravel substrates. Silt content and hence the organic levels were low, while clay content was moderately high. The higher silt content of the sediments appeared to be the main factor affecting the benthos, with 52% of the fauna as fine sediment feeders (mainly oligochaetes and sphaeriid clams). The only other major group was the grazers (on detritus), which comprised 45% of the fauna. Absent were the large densities of those species noted earlier as being strongly influenced by macrophyte density, which accounted for the relatively greater density of fine sediment feeders.

Station 0068, located at the southern tip of Fawn Island was situated in a sandy area (91%) very low in organic matter. Most of the fauna was detrital grazers such as the epibenthic G. fasciatus, or were algal grazers such as Goniobasis livescens. Together these comprised 83% of the fauna and included all but the oligochaetes and clams (the fine sediment feeders - 11%), the filterers (Hydropsyche), and the predators (Oecetis). Overall density of organisms was lower than at station 0064, and reflected the absence of aquatic macrophytes.

Sediments at Station 0034, located just north of the confluence of the Chenel Ecarte, contained a relatively greater amount of silt and hence organic content was higher as well. The density and biomass of organisms (Table 5.3 and 5.4) were high and was mainly concentrated in the grazers (algal and detrital) which included the most common species, such as

Polypedilum, Paratanytarsus, Gammarus fasciatus, Amnicola limosa, and Physella gyrina. Many of these as noted earlier are species that are commonly associated with aquatic macrophytes. In all, grazers comprised 85% of the total population, with sediment fine particle feeders (14%) and predators (1%) making up the remainder. The increased density of organisms seems to have occurred mainly in those groups associated closely with macrophytes (Polypedilum, G. fasciatus, and the gastropod species) and appears to be as a result of their occurrence.

The benthic community of the St. Clair River, as defined by these stations, differed considerably from the one described by Thornley (1985). Organic content at these stations appeared to be the main governing feature of the benthos and especially the occurrence of the fine sediment feeding community. Most of the latter are also those commonly considered as "tolerant" organisms and these would coincide with Thornley's "tolerant" group. It is likely the stations in the deeper, navigational channel would have larger accumulations of organic matter, and stations in that region would have been more comparable with Thornley's survey.

The stations sampled here were all located close to the east bank of the river, or near islands, and consisted mainly of sandy substrates. Organic matter was usually low, and much of this was in the form of coarse detritus. Macrophytes occurred in some areas and benthic density was much higher at these stations (0064 and 0034).

Only one area, station 0024, appeared to have suffered from external effects. Station 0066, also very low in organisms, appeared influenced mainly by unsuitable habitat type.

Summary

1) Sediment composition and organic content appeared to be the main determining factors of the benthos. High density occurred in upstream areas in Sarnia where organic content was high. Downstream areas yielded diverse faunas, with density and diversity affected most conspicuously by the presence of macrophytes.

2) Station 0024, located just south of Sarnia, appeared affected by contaminants. Though substrate (sandy/rocky) likely played a role in limiting the fauna, the extremely depauperate community bore strong evidence of chemical contamination.

3) Levels of all contaminants tested for were very low throughout the river and had no apparent effect on the benthic communities.

FIG:5.1 St. Clair R.,
Location of sampling stations,
Nov. 1985

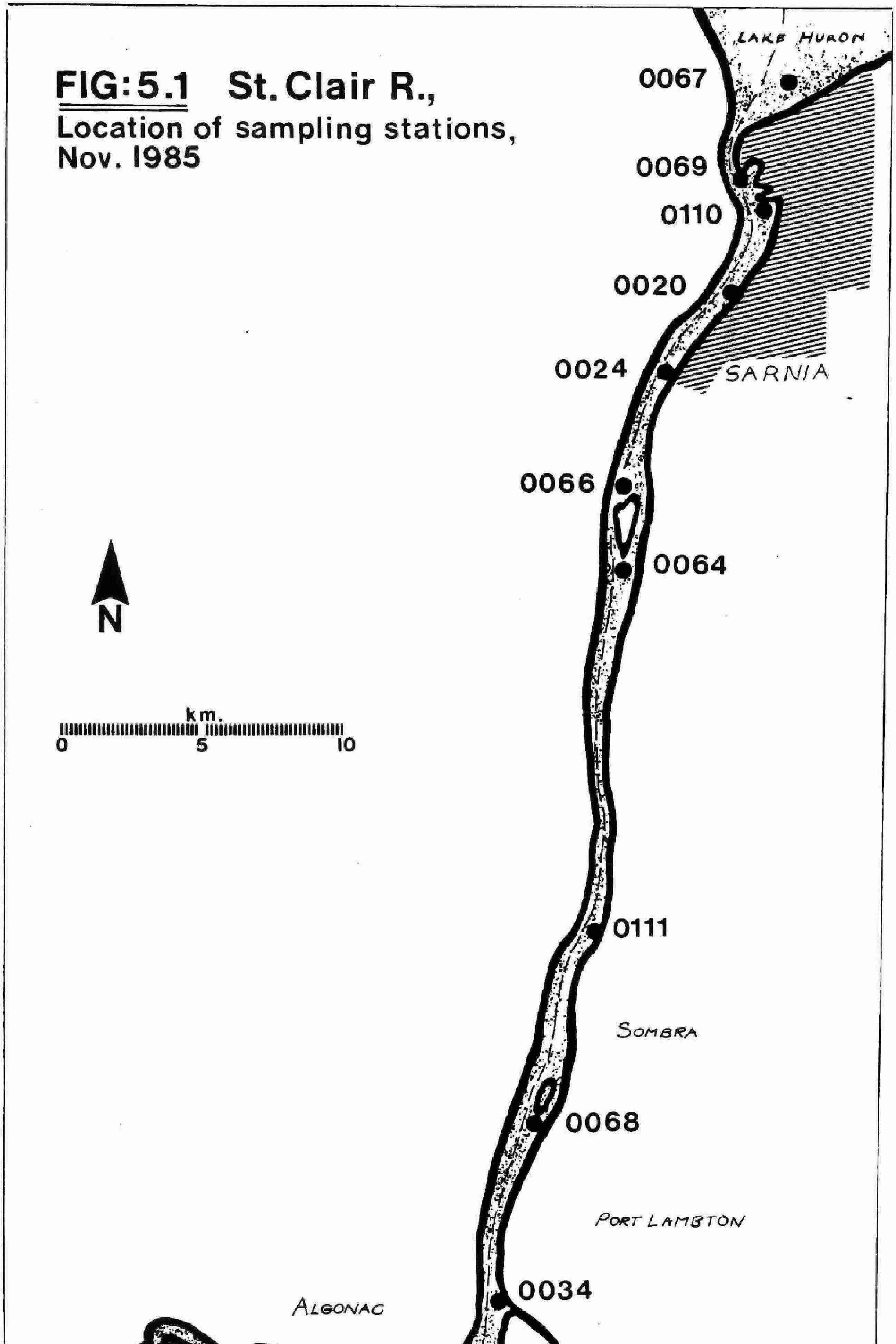

TABLE 5.1. WATER QUALITY DATA - ST. CLAIR RIVER. (1985) (TAKEN 1 M OFF BOTTOM).

Station Number	pH	Hardness (mg/l)	Chemical Oxygen Demand (COD) (mg/l)	Dissolved Organic Carbon (DOC) (mg/l)	Total Kjeldahl Nitrogen (TKN) (mg/l)	Turbidity	Suspended Particulate (mg/l)	Sodium (Na) (mg/l)	Chloride (Cl) (mg/l)
0067	8.18	98.0	6.3	1.5	0.150	5.30	7.72	3.34	5.77
0069	8.19	115.5	9.6	1.9	0.290	22.00	16.68	6.70	12.30
0110	8.12	102.0	13.7	1.6	0.160	12.80	12.57	3.73	6.55
0020	8.26	96.0	8.3	1.5	0.014	8.20	15.56	3.70	6.31
0024	8.27	99.5	9.2	1.6	0.180	11.70	9.42	9.16	14.00
0066	8.21	98.5	6.9	1.5	0.130	10.00	5.10	3.32	5.77
0064	8.22	99.0	6.5	1.5	0.180	6.90	6.44	3.35	5.79
0111	8.05	102.0	13.2	1.7	0.820	9.30	15.17	7.75	11.80
0068	8.20	98.0	6.0	1.5	0.150	3.70	5.23	5.08	8.16
0034	8.20	100.0	6.0	1.6	0.180	7.10	8.78	5.96	10.10

TABLE 5.2. SEDIMENT DATA - ST. CLAIR RIVER (1985).

Station Number	Grain Size (%) Gravel/Sand/Silt/Clay	Total Organic Carbon (TOC) (mg/g)	Loss on Ignition (LOI) (%)	Total Phosphorus (TP) (mg/g)	Total Kjeldahl Nitrogen (TKN) (mg/g)	Solvent Extractables (ug/g)
0067	-	-	-	-	-	-
0069	0/86/11/2	10.00	2.0	0.28	0.5	1,912.0
0110	0/83/13/3	9.20	1.4	0.25	0.6	602.0
0020	1/84/11/3	7.50	1.1	0.20	1.1	963.0
0024	-	-	-	-	-	-
0066	8/90/1/0	< 5.00	1.0	0.08	0.1	75.0
0064	1/78/16/3	9.60	1.4	0.22	0.7	718.0
0111	6/68/16/9	< 5.00	1.9	0.25	0.5	376.0
0068	0/92/6/1	< 5.00	0.7	0.21	0.2	187.0
0034	1/84/12/3	5.80	1.5	0.24	0.7	514.0

Station Number	Cu (ug/g)	Cr (ug/g)	Hg (ug/g)	Fe (ug/g)	As (ug/g)	Zn (ug/g)	Al (ug/g)	Total PCB's (ug/kg)
0067	-	-	-	-	-	-	-	-
0069	25.0	13.0	0.06	7,700.0	2.45	83.0	2,900.0	414
0110	18.0	12.0	0.04	6,600.0	2.35	45.0	3,300.0	< 20
0020	30.0	12.0	0.06	7,900.0	3.54	77.0	3,300.0	35
0024	-	-	-	-	-	-	-	-
0066	7.3	15.0	< 0.01	15,000.0	1.48	13.0	1,400.0	< 20
0064	15.0	12.0	0.02	8,800.0	3.54	40.0	4,300.0	< 20
0111	12.0	21.0	0.20	12,000.0	5.71	25.0	5,300.0	< 20
0068	13.0	9.9	0.16	6,900.0	2.55	37.0	2,200.0	-
0034	14.0	15.0	1.10	7,200.0	2.35	44.0	3,200.0	30

TABLE 5.3. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA - ST. CLAIR RIVER (1985)

All values are expressed as #'s per square meter.

	Station #0067		Station #0069		Station #0110	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera	10	0.2813			6	0.0056
O. Plecoptera						
O. Odonata						
O. Trichoptera	11	0.1957	5		23	0.0395
O. Coleoptera						
O. Diptera						
F. Chironomidae	37	0.0584	106	0.0196	562	0.4489
F. Ceratopogonidae						
F. Tipulidae			3			
F. Ceratopogonidae						
O. Lepidoptera					9	0.0159
Class Arachnida						
O. Acarina						
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	486	0.2490	9		402	0.8456
O. Isopoda			5		19	0.0419
MOLLUSCA						
Class Gastropoda	46	2.0921	38	0.3313	601	2.3027
Class Pelecypoda	14	0.6428			79	0.1932
COELENTERATA						
NEMATODA						
PLATYHELMINTHES						
Class Turbellaria						
ANNELIDA						
Class Hirudinea	1				8	0.094
Class Oligochaeta	5	0.0062	862	2.1914	149	0.1402
TOTAL # ORGANISMS	610		1,028		1,838	
TOTAL BIOMASS		3.5255		2.5423		4.1275
CORRECTED BIOMASS (+10%)		3.8781		2.7965		4.5403

TABLE 5.3. (Continued)

All values are expressed as #'s per square meter.

	Station #0020		Station #0024		Station #0066	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera						
O. Plecoptera					1	
O. Odonata						
O. Trichoptera	924	3.3277	6		35	
O. Coleoptera						
O. Diptera						
F. Chironomidae	61				14	0.0888
F. Ceratopogonidae						
F. Tipulidae						
F. Ceratopogonidae						
O. Lepidoptera						
Class Arachnida						
O. Acarina						
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	42	0.2175				
O. Isopoda						
MOLLUSCA						
Class Gastropoda	351	4.7458	22	0.4811		
Class Pelecypoda	174					
COELENTERATA			871			
NEMATODA					1	
PLATYHELMINTHES						
Class Turbellaria						
ANNELIDA						
Class Hirudinea	14	0.1938				
Class Oligochaeta	283	0.1644				
TOTAL # ORGANISMS	1,849		899		51	
TOTAL BIOMASS		8.6492		0.4811		0.0888
CORRECTED BIOMASS (+10%)		9.5141		0.5292		0.0977

TABLE 5.3. (Continued)

All values are expressed as #'s per square meter.

Station #0064		Station #0111		Station #0068		Station #0034	
Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
56	0.0559	41	0.059	17	0.0123	218	0.5113
				1			
368	0.3317	28	0.0111	34	0.0828	61	0.0488
		4				4	
2,566	2.6856	143	0.0883	19	0.0444	3,156	3.4286
						11	
		1	0.0021				
		1	0.0007				
1,049	3.3133	97	0.0709	115	0.0168	2,030	32.9693
153						5	
839	2.7786	241	9.8054	827	13.1308	781	2.7846
8		286	0.3051	3		594	1.1295
15	0.0123	1				57	0.0724
41	0.1861	18	0.1063				
41	0.1218	234	0.0804	47	0.0098	214	0.1011
9,175		1,095		1,063		7,131	
	9.4853		10.5293		13.297		11.0456
	10.4338		11.5822		14.6266		12.1502

TABLE 5.4. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - ST. CLAIR RIVER (1985)

SPECIES	STATION NUMBER (#/m²)									
	0067	0069	0110	0020	0024	0066	0064	0111	0068	0034
EPHEMEROPTERA:										
Ephemeridae: Hexagenia limbata	4						61	15	11	115
Caenidae: Caenis sp.								61		149
Baetiscidae: Baetisca lacustris	11									
Heptageniidae: Stenonema sp.	4									
PLECOPTERA										
Perlodidae: Isogenoides sp.						4				
TRICHOPTERA										
Hydropsychidae:										
Cheumatopsyche sp.					11	4				
Hydropsyche sp. 1		8		804			506		8	
Hydropsyche sp. 2				8						
Leptoceridae:										
Ceraclea sp						23				23
Mystacides sepulchralis	11						54		11	34
Oecetis sp.	4	8					107	15	8	11
Triaenodes sp.								23		11
Hydroptilidae:										
Ochrotrichia sp.									4	
Polycentropodidae:										
Nyctiophylax sp.							8			
DIPTERA										
Chironomidae:										
Chironomus thummi group		15	23							
Cryptochironomus sp.	4		8							
Demicryptochironomus sp.			31							
Dicrotendipes sp.								4	8	126
Endochironomus sp.		8		27			1,448	180		
Glyptotendipes (G.) sp.							268			
Microtendipes sp.	8									
Phaenopsectra sp.		8	172							
Polypedilum sp.			4							2,126
Cladotanytarsus sp.						4	590			
Paratanytarsus sp.									8	873
Rheotanytarsus sp.										11
Procladius sp.		61	123	31			38	4		34
Thienemannimyia complex			4						4	115
Potthastia longimana			4	8						57
Monodiamesa sp.			8							
Tipulidae:										
sp. indet.		8								
Ceratopogonidae:										
Palpomyia complex										11
LEPIDOPTERA										
Munroessa sp.			11							
COLEOPTERA										
Elmidae: Dubiraphia sp.								23		11
AMPHIPODA										
Gammaridae:										
Gammarus fasciatus	1,118		176	42			858	130	165	2,241
G. lacustris			88							
G. pseudolimnaeus		15								
ISOPODA										
Asellidae: Asellus sp.		8	23				31			
PELECYPODA										
Sphaeriidae:										
Pisidium sp.									8	
P. casertanum	8		57	54				322		506
P. conventus			8							
P. lilljeborgi			11					54		
P. walkeri				27				23		34
Musculium securis	8									
M. transversum							15			

TABLE 5.4. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - ST. CLAIR RIVER (1985) (Continued)

SPECIES	STATION NUMBER (#/m²) 0067	0069	0110	0020	0024	0066	0064	0111	0068	0034
GASTROPODA										
Valvatidae:										
Valvata sincera				54				38		
V. tricarinata			65	88			23			57
Hydrobiidae:										
Amnicola limosa	4		463	50			643	253	57	126
Bulimnea megasoma										34
Pleuroceridae:										
Goniobasis livescens	69				27			15	130	
Lymnaeidae:										
Lymnaea stagnalis				4						
Physidae:										
Physella gyrina sayi		8	153				123		11	345
Planorbidae:										
Gyralus parvus	4		77				84	23		46
Helisoma sp.									23	
Ancylidae:										
Ferrissia parallela					4					
HIRUDINEA										
Mooreobdella sp.				19						
Placobdella sp.	4									
Helobdella stagnalis							77			
H. lineata								23		
BRANCHIOBDELLIDA										
sp. indet.							8			
OLIGOCHAETA										
Naididae:										
Pristina sp.										69
Amphichaeta sp.				8						11
Enchytraeidae:										
sp. indet.	4	15	8					15		
Tubificidae:										
Spirosperma ferox		23		27				92		23
Quistadrilus multisetosus		38	27	92			8	161	50	69
Isochaetides freyi										11
Potamothrix moldaviensis			8				8			
L. udekemianus								15		
Immatures without capilliform setae		115	92	34			23	107		46
Total Number of Organisms	1,261	407	1,671	1,377	42	35	4,981	1,596	506	7,273
Species Diversity (H')	0.85	3.21	3.60	2.48	1.24	1.45	3.11	3.65	2.86	3.01
Species Richness (S.R.)	2.41	3.00	3.95	2.72	0.83	1.36	2.79	3.48	2.87	3.70
Evenness (J')	0.22	0.82	0.77	0.60	0.78	0.72	0.71	0.82	0.73	0.62

5.2 ST. CLAIR RIVER - FOLLOW-UP STUDY

Introduction

The survey of November 1985 indicated some effects were apparent on the benthic fauna in the region in which the perchloroethylene spill had occurred. That information was compared to a follow-up survey made in 1986 to determine if any long term effects resulted from this spill. Like the 1985 study, all stations in the 1986 survey were located along the eastern bank of the river, outside of the shipping channel (Fig. 5.2). With the exception of station 0110, located at the mouth of Sarnia Bay, stations were generally located near shore or near islands in moderately shallow areas (deepest was 5.5 m at station 203). Aquatic macrophytes occurred at many of the stations and sediments in these areas consisted mainly of sand with varying accumulations of silt.

Water Quality

Current velocity near the bottom (Table 5.5) was moderate in nearly all areas and only station 0110 had no detectable current. Dissolved oxygen content of the overlying water was consistently high at all stations. The river environment was well suited to the development and maintenance of a diverse benthic community.

Sediment Quality

Sediment organic content was relatively high at all stations, despite the fact that sand content was greater than 50% in each area sampled. Contaminant levels were also low throughout the river and rarely exceeded M.O.E guidelines.

Station 0110, located furthest upstream in Sarnia, was in a primarily sandy area moderately high in organic content. Contaminant levels were all low (Table 5.6) (data for organic contaminants was unavailable).

Station 203 was located at the south end of Sarnia (near the city's main industrial complex) also in a primarily sandy area. Organic content was still relatively high considering that sand comprised 78% of the sediment. Contaminant levels were moderately low and only Cu and Zn exceeded M.O.E. guidelines and then only by small amounts.

Sediments at station 218 were primarily sand and gravel (91% and 3% respectively) and organic content and contaminant levels were also moderately low. They were, however, higher than at station 0115, located furthest downstream, which had a lower sand content.

Stations 038A, 0064, and 0068 were all in areas of similar sediment type and ranged from 52% to 55% sand (37% to 42% silt). Organic content was also similar, though somewhat higher at station 0064. Sediment contaminant levels were all below guidelines except for Cu and Hg at station 0068, which were at or slightly above the limits.

Sediments were mainly sand at the remaining two stations (72% at station 0034; 83% at station 0115) and organic content varied accordingly. Contaminant levels were generally low and decreased with distance downstream. The exception was Hg, which was above M.O.E. guidelines at both stations.

Benthic Invertebrates

As seen from Table 5.8, each area sampled yielded benthic communities comprised of diverse groups representing a variety of ecological categories. These included epibenthic filter feeders (*Hydropsyche* and *Cheumatopysche* (Trichoptera)), epibenthic sediment feeders (*Oecetis* and *Triaenodes*), a sizeable community associated with the macrophytes (the gastropods *Gammarus* spp. and the chironomid *Endochironomus*), and the detritivores (the oligochaetes).

Located at the mouth of Sarnia Bay, station 0110 yielded a high density of those species closely associated with attached vegetation (aquatic macrophytes were present - M.O.E., unpublished data). These included the chironomid *Endochironomus*, which lives among the decaying vegetation that settles on the bottom, the amphipod *Gammarus fasciatus* and the snail *Amnicola limosa*. The later two species graze on the bacteria, microflora, and microfauna that occur on the leaves and stems of aquatic plants, as well as on decaying vegetation. In fact, 50% of the fauna was directly associated with macrophytes. The remainder of the fauna, comprised of oligochaete species, the clam *Pisidium casertanum* and the chironomid *Chironomus plumosus*, were all sediment feeders, either as filterers (*Pisidium* spp.), or as deposit feeders (the remainder).

Sand accounted for the major fraction of the sediment (74%) and this high percentage may have excluded some of the sediment inhabiting taxa. The absence of any detectable current may also have had an effect, especially upon the mayfly *Hexagenia limbata*, which was common at other downstream stations.

At the southern end of Sarnia, station 203 was located just upstream of the main industrial complex, situated in moderately deep water (5.5 m). This station yielded a diverse fauna rich in filter feeders such as the Hydropsychidae, and the various deposit feeders, such as the pelecypod and gastropod species (except *Amnicola limosa*). *Amnicola limosa* was the only species commonly associated with macrophytes.

The moderately strong current (27.8 cm/s; Table 5.5) would have favoured the filter feeders, such as *Hydropsyche* and *Cheumatopsyche*. Both species feed by passively filtering seston (current-borne detritus) out of the water and thus require a strong current in order to feed (Hynes 1970; Wiggins 1977). The increased current velocity would have allowed for little deposition of organic matter and this, coupled with a predominantly sandy substrate low in organic matter (Table 5.6), appeared to be the main cause of the low oligochaete density. Low organic matter was also judged to be the factor responsible for the lower density of *Gammarus fasciatus* at this location.

Station 218 was located in moderately shallow water off the north end of Stag Island along the eastern bank of the eastern channel (Fig. 5.5). Current velocity was moderate and sediments were almost entirely sand and gravel, overlain by fine sediments. Aquatic macrophytes also occurred at this station. The amphipod Gammarus fasciatus, various species of snails, and the oligochaetes, formed the majority of the fauna (Tables 5.7, 5.8). All are sediment deposit feeders, either on fine particulate matter or dead and decaying vegetation. The large population of amphipods was associated with macrophytes, feeding on microorganisms and other detritus both on living plants as well as decaying vegetation. The only other feeding group present was the predators, represented by the chironomid Procladius. Density and biomass of organisms were both high, despite the low organic matter of the substrate, and indicated that the organic matter contributed by the macrophytes played an important part in sustaining this community.

Located at the southwest end of Stag Island, station 038A consisted of a sand-silt substrate (54%-42%) and was situated in an area of moderately high current. The relatively strong current was primarily responsible for the high density of the filter feeding caddisfly Hydropysche, as well as the sediment feeding mayfly Hexagenia limbata, though the latter's water current requirements are tied to respiration and not to feeding. The remainder of the fauna was comprised of sediment feeders (collectors-detritivores) associated with decomposing vegetation, such as the chironomid Endochironomus. This species was the single most common organism, accounting for 33% of the total density and 8% of the biomass. Predators were represented solely by the chironomid Cryptochironomus. The greatest single factor determining the benthic community at this station appeared to be current velocity. Despite the moderately high organic content of the sediments, the density and biomass of the sediment feeders that was observed at station 218 was lacking at this locality.

Station 0064 was also located off the southern tip of Stag Island approximately 0.8 km downstream of station 038A. Though substrate conditions were nearly identical to station 038A (Table 5.6), there was a significant reduction in current at this location. Coupled with the slower flow regime was a near absence of the rheophilic caddisfly Hydropsyche. In contrast, very large populations of Endochironomus, the snail Amnicola limosa, and the mayfly Hexagenia limbata indicated a significant amount of coarse as well as fine organic matter has accumulated in this area. As a result, the community consisted almost entirely of sediment deposit feeders (85% of the density) and the filter feeders that comprised almost 24% of the fauna upstream were lacking. Though overall density at station 0064 was increased by more than 100% over that recorded at station 038A, biomass had increased only 20%, indicating the increase in density was mainly in small organisms.

Station 0068 was located in the entrance to a small bay off Fawn Island. Substrate type and composition were very similar to the preceding two stations, though current velocity was moderately high (Tables 5.5, 5.6). This station yielded the most diverse fauna of any of the stations sampled, as denoted by the species diversity index H' (Table 5.8). Much of

this diversity arose from the varied chironomid fauna, the majority of which are sediment deposit feeders (excluding only the carnivorous Procladius). Similarly, the mayfly fauna (Hexagenia limbata), the caddisfly fauna, the molluscs, and the oligochaetes are all deposit feeders (detritivores) either in or on the sediments. Absent were the high densities of Gammarus fasciatus and Amnicola limosa associated with aquatic macrophytes.

Located near the entrance to the Ecarte Channel (Chanel Ecarte), station 0034 was in an area of a predominantly sandy substrate and moderately low current velocity (11.4 cm/s). The benthic fauna consisted primarily of fine sediment detritivores, such as Hexagenia limbata, various species of chironomids, the clam Pisidium and the oligochaetes. In fact, only those species either feeding on bottom sediments or preying on this fauna were present, indicating a lack of other suitable habitat.

Station 0115 was located approximately 1 km south of station 0034 along the shoreline of Walpole Island, in shallow water (1.5m; Table 5.6). The presence of the macrophyte Chara sp. (M.O.E., unpublished data) appears to have determined the character of much of the fauna. Burrowers in the sediment were few (mainly Hexagenia limbata with very few oligochaetes), which was likely a result of the mainly sand substrate low in organic matter (Table 5.6). The most common organisms were Endochironomus and Gammarus fasciatus, both of which are common in areas with aquatic macrophytes.

In general a number of trends became evident. Though a diverse and sizeable benthic community existed at all the stations sampled, density, species composition, and biomass did vary markedly among stations. The major determinant of the benthic community appeared to be current velocity. Stations 203, 038A, and 0068, all of which had moderately high current, yielded similar faunas despite the difference in substrate composition. Density and biomass at all three stations was low in comparison to some of the other stations.

The other major determinant of benthic community composition was the occurrence of attached vascular plants, which, according to M.O.E. field data, were most prevalent at stations 0110, 218, 0064 and 0115. A similar fauna was dominant at all four of these stations and was characterized by the amphipod Gammarus fasciatus, the snail Amnicola limosa, and the chironomid Endochironomus. Density and biomass were very similar at all the stations.

Organic matter content of the sediment was low at nearly all the stations and the oligochaete and Pisidium populations were correspondingly low as well.

Since no station was sampled immediately downstream of the industrial complex at Sarnia no direct comparison with the 1985 survey results can be made. However, there appear to be no discernable effects on the benthic fauna at any of the stations sampled. All yielded diverse populations comprised of species commonly indicative of relatively clean waters, such

as Hexagenia limbata and the Trichoptera species. Physical and chemical analyses of the sediments and overlying water showed little difference among the stations except those already noted. Levels of metals and other chemicals (Table 5.6 and M.O.E. unpublished data) yielded low values, none of which exceeded M.O.E. guidelines.

Comparison of these results with the 1985 survey (stations 0110, 0064, 0068, and 0034) yielded similar faunas and densities at stations 0064 and 034. Stations 0110 and 0068 yielded much higher densities of organisms in this survey. Presumably differences in microhabitat are responsible, especially at station 0110, which showed a marked increase in those taxa associated with aquatic macrophytes.

Summary

1) The benthic community at all stations was very diverse, not only in species present but in the feeding groups they represented.

2) The major factors affecting invertebrate distributions seemed to be current velocity, substrate composition, and the presence of macrophytes.

3) No adverse effects of any type could be determined from the benthic community at any of the stations.

4) Chemical analysis of the sediments supports this interpretation since no major differences were found among the stations sampled.

5) Results are comparable to the 1985 survey. The differences are most likely due to microhabitat differences since they consisted mainly of an increase in density of comparatively clean-water forms.

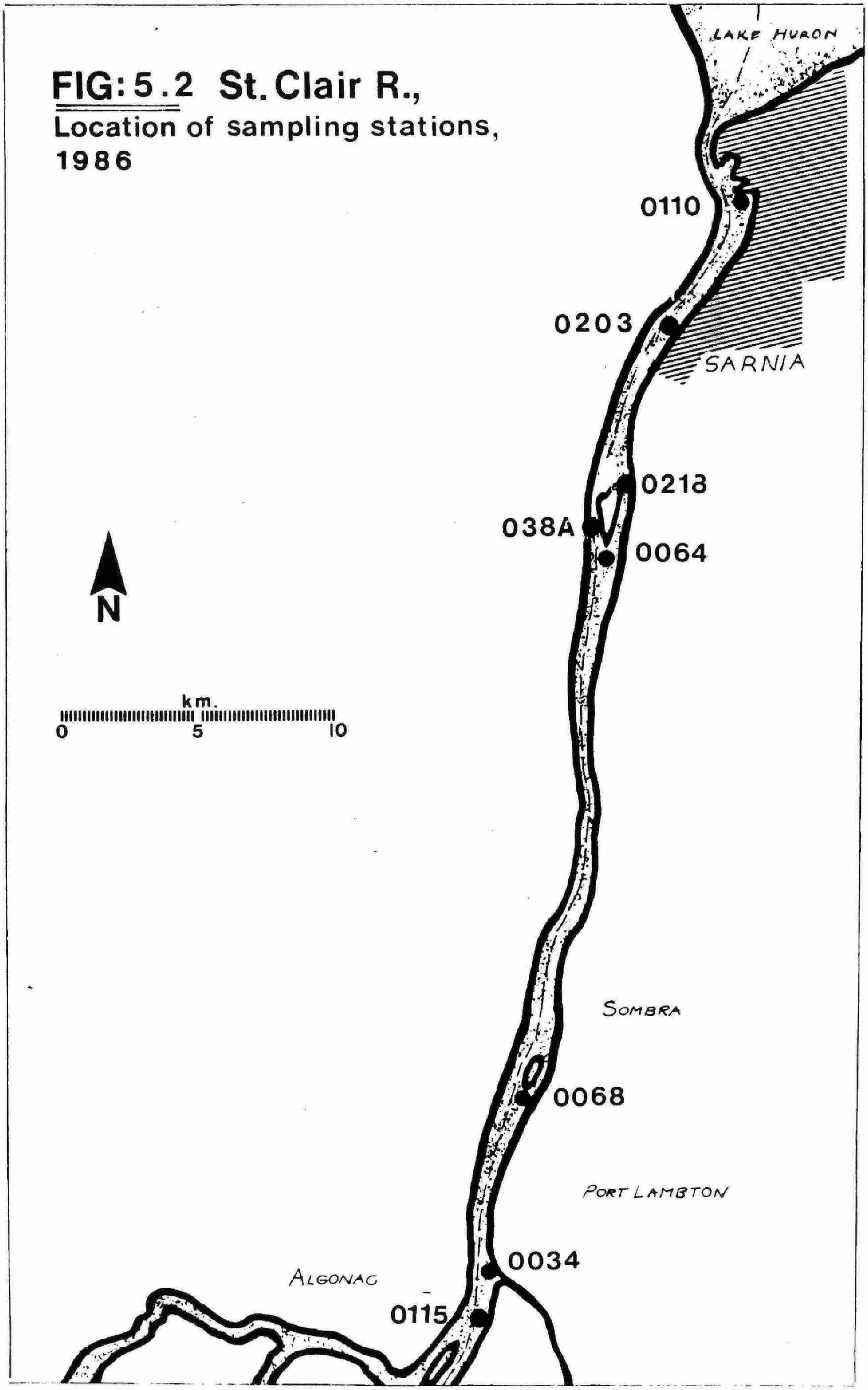

FIG: 5.2 St. Clair R.,
Location of sampling stations, 1986

TABLE 5.5. WATER QUALITY DATA - ST. CLAIR RIVER (1986) (TAKEN 1 M OFF BOTTOM).

Station Number	Depth (m)	Dissolved Oxygen (ppm)	pH	Current (cm/s)	Hardness (mg/l)	Chemical Oxygen Demand (COD) (mg/l)	Dissolved Organic Carbon (DOC) (mg/l)	Total Kjeldahl Nitrogen (TKN) (mg/l)	Turbidity
0110	4.0	10.9	8.25	0.0	100.0	< 2.0	2.9	0.40	3.30
203	4.0	10.8	8.26	27.8	98.5	< 2.0	2.6	0.40	1.28
218	2.0	10.4	8.20	16.6	108.5	16.0	4.8	0.40	2.30
038A	3.0	10.7	8.25	32.1	96.0	14.0	6.5	0.40	1.98
0064	5.5	10.8	8.25	21.7	98.5	16.0	2.8	0.40	2.60
0068	3.0	10.7	8.24	32.1	97.5	6.0	2.2	0.40	2.10
0034	3.5	10.6	8.24	11.4	100.5	< 2.0	2.1	0.40	1.32
0115	1.5	10.8	8.25	6.3	100.5	< 2.0	1.5	0.40	3.60

TABLE 5.6. SEDIMENT DATA - ST. CLAIR RIVER (1986).

Station Number	Depth (m)	pH	Eh (mv) 1 cm/3 cm	Grain Size (%) Gravel/Sand/Silt/Clay	Total Organic Carbon (TOC) (mg/g)	Loss on Ignition (LOI) (%)	Total Phosphorus (TP) (mg/g)	Total Kjeldahl Nitrogen (TKN) (mg/g)
110	4.0	7.07	-73/-156	0 / 74 / 24 / 2	21.0	(20.0)	0.28	0.7
203	5.5	7.34	-80/ -	0 / 78 / 16 / 5	15.0	(11.0)	0.24	0.4
218	2.2	6.97	-25/-140	3 / 91 / 5 / 2	11.0	11.0	0.23	0.4
38A	3.0	7.62	-224/ -	0 / 54 / 42 / 3	20.0	(17.0)	0.27	0.9
64	5.0	7.50	-131/ -	4 / 55 / 37 / 3	26.0	24.0	0.31	1.1
68	4.5	6.98	-30/ -85	0 / 52 / 40 / 8	21.0	(19.0)	0.28	0.6
34	3.6	6.96	-18/-106	0 / 72 / 26 / 2	20.0	(19.0)	0.30	0.7
115	1.0	7.55	-5/ -	0 / 83 / 15 / 2	12.0	(10.0)	0.26	0.5

Station Number	Cu (ug/g)	Cr (ug/g)	Hg (ug/g)	Fe (ug/g)	As (ug/g)	Zn (ug/g)	Al (ug/g)
110	22.0	19.0	0.05	7800.0	4.5	44.0	4200.0
203	29.0	16.0	0.07	7800.0	4.9	110.0	3100.0
218	15.0	19.0	1.80	6000.0	1.9	37.0	2700.0
38A	21.0	19.0	< 0.01	8700.0	4.4	44.0	4900.0
64	14.0	20.0	0.02	9600.0	5.7	51.0	4900.0
68	25.0	19.0	0.36	8800.0	3.7	46.0	4800.0
34	18.0	22.0	0.41	9400.0	4.0	51.0	3800.0
115	9.3	13.0	0.42	4800.0	1.6	37.0	2700.0

TABLE 5.7. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA - ST. CLAIR RIVER (1986)

All values are expressed as #'s per square meter.

	Station #0110		Station #0203		Station #0218	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera			8	0.0158	19	0.0033
O. Odonata					19	0.0462
O. Trichoptera	8	0.0043	831	1.7800		
O. Diptera						
F. Chironomidae	2,241	1.3778	123	0.0380	594	0.0767
F. Ceratopogonidae						
O. Lepidoptera					19	
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	4,099	5.2718	260	0.1673	3,888	2.1612
O. Isopoda	824	1.5718	4	0.0043		
MOLLUSCA						
Class Gastropoda	1,053	1.7820	1,820	25.8423	1,705	9.5253
Class Pelecypoda	824	1.3820	410	1.3218	230	0.2097
ANNELIDA						
Class Hirudinea	38	0.1255	23	0.3803	19	0.3210
Class Oligochaeta	1,934	0.9078	383	0.1457	5,478	1.7218
TOTAL # ORGANISMS	11,013		3,862		11,971	
TOTAL BIOMASS		12.4230		29.6955		14.0652
CORRECTED BIOMASS (+10%)		13.6653		32.9621		15.4717

TABLE 5.7. (Continued)

All values are expressed as #'s per square meter.

	Station #038A		Station #0064		Station #0068	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera	682	0.8525	984	1.2578	613	2.5032
O. Odonata						
O. Trichoptera	739	1.2897	421	0.1846	149	0.4021
O. Diptera						
F. Chironomidae	1,628	0.6598	6,006	1.4588	1,153	0.3969
F. Ceratopogonidae	4				23	0.0013
O. Lepidoptera			4	0.0064		
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	751	1.6348	1,023	1.1023	206	0.3174
O. Isopoda	65	0.1184	138	0.3350		
MOLLUSCA						
Class Gastropoda	824	3.0033	1,153	3.6054	211	0.5605
Class Pelecypoda	119	0.3186	245	1.0621	115	0.3605
ANNELIDA						
Class Hirudinea	4		27	0.0393		
Class Oligochaeta	165	0.0606	992	0.6153	621	0.2711
TOTAL # ORGANISMS	4,981		10,993		3,091	
TOTAL BIOMASS		7.9377		9.6670		4.8130
CORRECTED BIOMASS (+10%)		8.7315		10.6337		5.2943

TABLE 5.7. (Continued)

All values are expressed as #'s per square meter.

Station #0034		Station #0115	
Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
345	0.5330	881	0.2659
		161	0.1209
2,835	0.9123	3,792	3.8615
		77	0.0168
326	0.5288	2,287	1.3605
19	0.0690	84	0.1173
421	2.4995	146	5.0080
785	1.2025	31	0.0879
1,494	0.4845	80	0.0689
6,225		7,539	
	6.2296		10.9077
	6.8526		11.9985

TABLE 5.8. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - ST. CLAIR RIVER (1986).

SPECIES	STATION NUMBER (#/m²) 0110	203	218	038A	0064	0068	0034	0115
EPHEMEROPTERA								
Ephemeridae: Hexagenia limbata		19		555	2,241	689	594	460
Caenidae: Caenis sp.				134				575
TRICHOPTERA								
Leptoceridae:								
Oecetis sp.					230	57		
Mystacides sepulchralis						96		230
Triaenodes sp.					230			
Hydropsychidae:								
Hydropsyche sp.		689		1,264	57			
Cheumatopsyche sp.		77						
Polycentropodidae:								
Nyctiophylax sp.				38				
Polycentropus sp.							19	
LEPIDOPTERA: Munroessa sp.			57				19	
DIPTERA								
Ceratopogonidae: Palpomyia group				19				57
Chironomidae:								
Chironomus sp.							211	
C. plumosus group	996							
Endochironomus sp.	651		57	1,647	11,664			3,390
Cryptochironomus sp.				134	287			
Demichryptochironomus sp.						19		
Microtendipes sp.				77				
Paratendipes sp.							287	
Pseudochironomus sp.					460	383		1,226
Stictochironomus sp.						211	211	
Procladius sp.	192		1,073		402	460	77	
Thienemannimyia group						19	77	
Potthastia longimana							38	
Cricotopus bicinctus group		38						
Epoicocladius sp.						19		
ISOPODA: Asellidae: Asellus sp.	843			77				96
AMPHIPODA								
Gammaridae:								
Gammarus fasciatus	4,060		4,290	306	689	134	96	2,739
G. lacustris		402						
GASTROPODA								
Physidae: Physella gyrina sayi	383	192	555	77		57		
Valvatidae:								
Valvata sincera			153					
V. tricarinata	115	230	153	57				
Planorbidae: Gyralus parvus	115							
Pleuroceridae: Pleurocera acuta		479						
Hydrobiidae: Amnicola limosa	1,915	1,781		689	1,781	211		57
Ancylidae: Ferrissia parallela			249					
Lymnaeidae: Lymnaea stagnalis			306					
PELECYPODA								
Sphaeriidae:								
Pisidium casertanum	1,034		517			96	594	57
P. lilljeborgi							172	
P. walkeri		249		96	345			
HIRUDINEA								
Glossiphonia heteroclita		19			57			
Helobdella stagnalis	77							
Dina sp.		19						
OLIGOCHAETA								
Tubificidae:								
Aulodrilus americanus	306			77				
Limnodrilus hoffmeisteri	498		211			57	38	
Quistadrilus multisetosus	881	19						
Potamothrix moldaviensis					115	172	38	
Spirosperma ferox		192	1,685	57	115	192	1,245	77
Immatures with capilliform setae			211					
Immatures without capilliform setae	766	38	2,547	19	575	555	306	96
Lumbriculidae: Stylodrilus heringianus						57	96	
Total Number of Organisms	12,832	4,443	12,064	5,323	19,248	3,465	4,118	9,060
Species Diversity (H')	3.22	2.81	2.80	2.95	2.17	3.53	3.23	2.38
Species Richness (S.R.)	1.48	1.67	1.38	1.86	1.42	2.08	1.92	1.21
Evenness (J')	0.82	0.72	0.73	0.72	0.55	0.85	0.79	0.66

6. DETROIT RIVER

Introduction

The Detroit River is one of the most industrialized waterways investigated in this survey. In the Detroit area, a large number of industries are located along the river, or its tributaries, and as a result a great number of contaminants have been found in the river sediments to date (I.J.C. 1987).

Water Quality

Water quality in the Detroit River was similar to conditions in the St. Clair River and was characterized by moderately hard water and relatively high pH. Organic content was low, as were turbidity and suspended particle load, though conditions were variable (Table 6.1).

Sediment Quality

Sediment conditions varied from silt to predominantly sand and gravel. Organic content, and hence, contaminant levels, also varied widely, the latter being very high at the areas with highest organic levels (Table 6.2).

Located on the north side of Belle Isle near Lake St. Clair, station 0104 was in an area of predominantly sand and gravel, low in organic content. Contaminant levels for most parameters were below M.O.E. guidelines.

Station 0101, located at the western end of Windsor on the Ontario side of the river, was situated at the mouth of a small bay, which apparently formed a depositional area. Silt content (39%) and clay (16%) were higher than at station 0104 while sand comprised 39% of the substrate, resulting in an equal sand-silt mix. Organic content was considerably higher than at station 0104, as were contaminant levels, and all exceeded the guidelines, though Zn had increased by the most significant amount (Table 6.4).

Station 0103, located just south of the Rouge River on the Michigan side of the river, was also in a sand-silt substrate (51%-33%). Organic matter was high and contaminant levels greatly elevated, particularly PCBs and solvent extractables, which in the case of the former were nearly 60 times M.O.E. guidelines (Table 6.4). Zn and Fe levels were also significantly higher exceeding guidelines by 15 and 12.5 times respectively. Most noticeable, though, was the rapid increase in these levels over those at station 0101, in what was a relatively short section of the river. Pesticide levels, while also low upstream, rose significantly in this area (Table I, pg.52) and levels continued high or rose even further at stations 0062 and 0085.

Located 3 km downstream of station 0103 along the Michigan side of the

river, station 0062 yielded sediments that were mainly sand (61%) with a relatively low silt content (26%). Organic content was high and levels of all contaminants were very high, with PCB's and solvent extractables particularly so (Table 6.4). Solvent extractables were 15 times higher than M.O.E. guidelines while PCBs were 75 times higher than these limits. Pesticide levels were considerably higher than at station 0103.

Table I: Levels of Selected Pesticides in the Detroit River (ng/g)

compound \ station	0104	0101	0103	0062	0085	0070
A-Chlordane	6	10	14	7	38	< DL
G-Chlordane	< DL	< DL	7	10	20	< DL
Dieldrin	2	< DL	13	16	16	< DL
DMDT Methoxychlor	< DL	< DL	100	57	614	< DL
Endosulfan 1	< DL	10	5	5	35	< DL
Endosulfan 11	< DL	< DL	4	12	33	< DL
Endrin	< DL	< DL	11	15	46	< DL
Endosulfan sulphate	< DL	< DL	19	17	112	< DL
Heptachlor epoxide	< DL	< DL	12	11	40	< DL

< DL - below detection limit

Station 0075, located at the mouth of the Ecorse River, appeared to be in an erosional area. Sediment data were unavailable and the extremely reduced benthic fauna was not able to indicate whether substrate or contaminant levels were the major factors.

Station 0085 was located in the western channel near the north end of Grosse Island. Sediments were mainly silts (61%), while clays also formed a large fraction (24%). Organic content was high and contaminant levels were also very high. PCBs and solvent extractables, as well as some of the metals, continued to be the most elevated, though levels had decreased slightly from those at station 0062.

Sediment data were also lacking for station 0072, approximately 3 km south of station 0085, again on the Michigan side of the river. Hard substrate is presumed to have predominated in this area.

Located near the mouth of the Detroit River, station 0070 was situated in a predominantly sand-gravel area (87% : 3%). Silt content and organic levels were lower, as were levels of most contaminants, though 7 of 8 parameters in Table 6.2 exceeded M.O.E. guidelines. Levels of solvent extractables and PCBs were considerably reduced from upstream areas, though this may have more to do with the mainly sandy substrate than with an actual downstream reduction in contaminant levels.

The two stations located on the Ontario side of the river at Fighting Island were markedly different from the other stations.

Station 0100 was situated in a sand-silt area (42% : 44%) of moderately high organic content, located on the eastern side of Fighting Island. Contaminant levels, in contrast to levels on the Michigan side, were relatively low and only a few slightly exceeded M.O.E. guidelines, with levels of PCBs and solvent extractables well below (Table 6.4).

Station 0102, located in a predominantly sandy area approximately 1 km south of Fighting Island, had even lower levels of contaminants despite a moderately high organic content. All levels were well below guidelines.

Benthic Invertebrates

Sand - silt sediments predominated at most of the stations sampled and this in turn defined the benthic community, at least at the uncontaminated areas.

Located on the north side of Belle Isle near Lake St. Clair, station 0104 was in an area of predominantly sand and gravel low in organic content. The benthic fauna appeared to be typical of most large rivers, though rather reduced in density and biomass of organisms (Table 6.3), for which the high sand content was the most likely cause. Sediment fine particle feeders (oligochaetes) formed 78% of the fauna and consisted primarily of the common species Quistadrilus multisetosus and Limnodrilus spp., though in very low densities (Table 6.4). Filterers (Hydropsyche) and detrital feeders (Hyalella azteca) comprised the remainder of the fauna. The low numbers of all these organisms pointed to sediments, specifically the low organic content, as the main factor.

Station 0101, located at the western end of Windsor on the Ontario side of the river, was situated at the mouth of a small bay, which formed a depositional area. Silt content (39%) and clay (16%) were higher than at station 0104, while sand comprised 39% of the substrate, resulting in an equal sand-silt mix. Organic content was considerably higher than at station 0104 and sediment fine particle feeders were the most prevalent group, of which Hexagenia limbata was a particularly large component (40% of the fine particle feeders, which themselves comprised 68% of the fauna). Predators (Procladius) and grazers comprised the remainder of the fauna (Table 6.4). The high density of H. limbata was dictated by the sand-silt sediment type (the preferred habitat type; Edmunds et al. 1976). This same feature could have served to limit many of the other sediment feeders, such

as the oligochaetes.

Station 0103, located just south of the Rouge River on the Michigan side of the river, was also in a sand-silt substrate (51%-33%) of high organic content. The benthic community, as a result of the high silt and organic content, was comprised mainly of fine sediment feeders (99%) of which the Tubifex tubifex--Limnodrilus spp. community was dominant. Organic enrichment appeared to be the main cause, though contaminant levels could have played a part in the elimination of the H. limbata and chironomid communities that were present upstream since levels of many of these were greatly elevated in comparison to upstream stations.

Located 3 km downstream along the Michigan side of the river, station 0062 yielded a very similar benthic fauna. Sediments were mainly sand (61%) with a relatively low silt content (26%), though organic content was high. The benthic fauna consisted primarily of oligochaetes, and the fine sediment feeders as a whole comprised upwards of 95% of the fauna. Only the well known, pollution tolerant Limnodrilus species were present. The high density of oligochaetes at both station 0103 and this station, despite the very high contaminant levels, indicated that these materials, in particular the PCBs and pesticides, may not have been readily available to the benthic fauna. They are implicated as one of the likely causes for the absence of Hexagenia as well as the Trichoptera, the chironomid and the gastropod species that were present at upstream locations. The other major factor is the dramatic rise in pesticide levels that became evident from this station on downstream.

Station 0075, located at the mouth of the Ecorse River, appeared to be in an erosional area. Sediment data were unavailable, but the benthic data indicated this was an unsuitable area for benthic invertebrates though whether this was due to physical conditions (erosional substrate) or chemical conditions is unclear from the benthic data (Table 6.4).

Station 0085 was located in the western channel near the north end of Grosse Island. Sediments were mainly silts (61%) while clays (24%) also formed a large fraction. Organic content was high, as were contaminant levels. Despite the high organic content, density of organisms was very low and consisted of a small population of fine sediment feeders (oligochaetes). While the higher clay content may have had some limiting effect, levels of most of the parameters were very high in this area (Table 6.2) and this included polycyclic aromatic hydrocarbons and pesticides as well (M.O.E. unpublished data) which were the highest of any areas sampled (Table I). Evidently, a whole range of contaminants were at work in this area. The diverse, though depauperate oligochaete fauna indicates that chemical conditions override the physical nature of the habitat, since all of the oligochaete species, including Limnodrilus spp. were severely reduced in density. In fact a very similar type of fauna also existed at station 0075, though not as severely reduced in density.

Sediment data were also lacking for station 0072, approximately 3 km south of station 0085 again on the Michigan side of the river. Benthic data (Table 6.4) showed this area to be extremely reduced in benthic

organisms, though the cause for this cannot be determined with any certainty. A lack of suitable soft substrate may have been the cause, though usually sandy-gravelly substrate merely results in a shift of species, rather than the wholesale elimination of taxa, as was evident at this station. It appeared likely that when upstream conditions were considered, a combination of adverse physical and chemical conditions were responsible for this reduction.

Located near the mouth of the Detroit River, station 0070 was situated in a predominantly sand-gravel area (87% : 3%). Silt content and organic levels were lower as were the levels of most contaminants (Table 6.2 and Table I). Benthic density and diversity were higher than they had been since station 0062 and consisted not only of fine sediment feeders (oligochaetes and Chironomus plumosus) but some epibenthic grazers (amphipods) as well. Fine sediment feeders, at 94%, comprised most of the fauna.

The higher density of organisms at this station, despite the low organic content of the sediments, lends further credence to the claim that contaminant levels were responsible for the depauperate communities at stations 0075, 0085, and 0072.

The two stations located on the Ontario side of the river at Fighting Island were markedly different from the other stations.

Station 0100, situated in a sand-silt area (42% : 44%) of moderately high organic content, was located on the eastern side of Fighting Island. Contaminant levels, in contrast to levels on the Michigan side, were relatively low and only a few slightly exceeded M.O.E. guidelines (Table 6.2). A very diverse benthic fauna existed at this location which was dominated by the algal grazers such as Agraylea (32% of the fauna). Detrital grazers (28%) and fine sediment feeders (27%) comprised most of the remainder while predators comprised the final 13%. Density of organisms was high and could be considered indicative of relatively unaffected sections of the river.

Station 0102, located in a predominantly sandy area approximately 1 km south of Fighting Island, also yielded a diverse benthic community and indicated that even sandy areas would normally contain large and diverse populations of invertebrates, since despite the low organic content and high sand content (91%), a large community of benthic organisms was found (diversity was highest of any station in the Detroit River (H'= 3.51; Table 6.4)). These were mainly epibenthic, and were either grazers on detritus or algae. Fully 62% of the fauna was comprised of grazers with only 33% of the fauna as sediment infauna (mainly oligochaetes) while predators made up the remaining 5%.

In summary, both of these stations appeared to be comprised of a normal community of river species. As such they contrasted sharply with conditions in the main river channel, along the Michigan side of the river. A gradual, steady deterioration of benthic conditions was evident with increasing distance downstream. Furthest upstream, station 0104 was

closest to the normal condition for sandy areas in the main river. This was followed by an organically polluted zone in the upper area of the river (station 0103). The transition was characterized by steadily increasing organic matter and contaminant levels. The increasing organic content was consistent with Thornley's characterization of this area (Thornley 1982). The benthos consisted primarily of oligochaetes in high densities while many of the clean-water species disappeared.

This was followed in the middle and lower sections of the river by organically enriched and contaminated areas (stations 0062 and 0085 and apparently 0075 and 0072 as well) which were characterized by severely reduced benthic communities. The benthic communities normally associated with organic pollution were also extremely reduced in this section, though at station 0085 organic content and substrate type did not appear to be limiting factors. High levels of pesticides and other organics (PCBs) in the sediments were strongly implicated as the major causes for these reductions. High levels of metals do not appear to have any major effect, for the reasons discussed earlier in this report (Section 3.1.1).

A minor recovery of this pollution tolerant fauna was apparent at station 0070, the furthest station downstream. Despite the similarity of the substrates at this station and station 0104, furthest upstream, the clean-water forms noted at the latter did not reappear.

The two stations located on the Ontario side yielded the most diverse communities of any in the study area. Contaminant levels were low at both of these areas and had no apparent effect on the benthic fauna.

<u>Summary</u>

1) Areas along the Ontario side of the river appeared to be much less affected than areas along the Michigan side. Areas along the Ontario side contained normal, diverse river faunas. These areas (stations 0100 and 0102) were low in sediment contaminant levels.

2) The main river channel showed a progressive deterioration of conditions with increasing distance downstream. Upstream areas were mainly organically polluted while downstream areas appeared to be chemically contaminated as well. The benthic communities were extremely reduced, though any one contaminant, of the plethora of available possibilities, cannot be singled out.

3) A reduction in levels of chemical contamination to a situation of simply organic pollution was apparent near the mouth of the river. Some recovery of the benthos was evident as well.

FIG:6.1 Detroit R.,
Location of sampling stations, Nov. 1985

TABLE 6.1. WATER QUALITY DATA - DETROIT RIVER (TAKEN 1 M OFF BOTTOM).

Station Number	pH	Hardness (mg/l)	Chemical Oxygen Demand (COD) (mg/l)	Dissolved Organic Carbon (DOC) (mg/l)	Total Kjeldahl Nitrogen (TKN) (mg/l)	Turbidity	Suspended Particulate (mg/l)	Sodium (Na) (mg/l)	Chloride (Cl) (mg/l)
0104	8.28	92.5	9.2	1.8	0.400	13.00	7.66	5.57	9.70
0101	8.14	111.5	12.6	2.3	0.310	14.10	23.73	5.57	10.25
0103	8.13	107.0	10.1	1.8	0.230	8.60	11.74	6.29	10.95
0062	8.23	94.0	10.5	2.0	0.310	10.80	21.83	6.51	12.65
0075	7.94	111.0	10.1	2.0	0.320	6.60	13.65	8.80	15.40
0100	8.21	112.0	8.5	2.1	0.300	20.00	17.53	13.80	23.00
0085	8.04	105.5	8.1	2.0	0.660	3.40	5.07	11.10	16.45
0102	8.30	96.0	8.5	2.1	0.330	13.20	14.86	17.60	28.45
0072	7.97	96.0	7.8	1.9	0.580	10.70	9.76	8.67	13.05
0070	8.03	91.0	10.5	1.9	0.540	7.90	13.92	8.46	12.75

TABLE 6.2. SEDIMENT DATA - DETROIT RIVER.

Station Number	Grain Size (%) Gravel/Sand/Silt/Clay	Total Organic Carbon (TOC) (mg/g)	Loss on Ignition (LOI) (%)	Total Phosphorus (TP) (mg/g)	Total Kjeldahl Nitrogen (TKN) (mg/g)	Solvent Extractables (ug/g)
0104	1/91/6/2	< 5.0	0.6	0.30	0.3	770.0
0101	3/39/39/17	40.0	4.0	0.71	1.3	1,170.0
0103	0/51/34/12	77.0	8.0	1.11	1.6	12,569.0
0062	0/61/27/10	46.0	4.9	1.73	0.9	22,905.0
0075	-	-	-	-	-	-
0100	0/43/44/8	19.0	2.8	0.47	1.1	473.0
0085	0/12/62/24	74.0	12.0	4.96	7.1	7,381.0
0102	0/91/7/2	< 5.0	0.5	0.20	0.3	270.0
0072	-	-	-	-	-	-
0070	3/88/7/2	12.0	1.0	0.68	0.4	371.0

Station Number	Cu (ug/g)	Cr (ug/g)	Hg (ug/g)	Fe (ug/g)	As (ug/g)	Zn (ug/g)	Al (ug/g)	Total PCB's (ug/kg)
0104	39.0	18.0	0.29	7,900.0	1.77	81.0	2,900.0	55
0101	54.0	44.0	0.31	28,000.0	12.50	260.0	16,000.0	60
0103	100.0	140.0	0.40	125,000.0	12.30	1,500.0	9,100.0	2,970
0062	17.0	200.0	0.45	110,000.0	14.40	750.0	7,300.0	3,760
0075	-	-	-	-	-	-	-	-
0100	28.0	30.0	0.45	16,000.0	5.19	79.0	9,800.0	< 20
0085	130.0	140.0	1.10	35,000.0	10.90	780.0	14,000.0	2,165
0102	6.0	10.0	0.05	4,700.0	1.00	28.0	2,600.0	< 20
0072	-	-	-	-	-	-	-	-
0070	160.0	38.0	0.58	22,000.0	9.26	160.0	3,500.0	105

TABLE 6.3. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA - DETROIT RIVER

All values are expressed as #'s per square meter.

	Station #0104		Station #0101		Station #0103	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera	5	0.0125	128	1.2204		
O. Odonata						
O. Trichoptera	22	0.0099	4	0.0017		
O. Diptera						
F. Chironomidae	1		126	0.1271		
F. Empididae						
O. Lepidoptera						
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	4		1		5	
O. Isopoda			1			
MOLLUSCA						
Class Gastropoda	4}					
		9.9722				
Class Pelecypoda	5}		15	0.0606		
PLATYHELMINTHES						
Class Turbellaria						
ANNELIDA						
Class Hirudinea			8	0.011		
Class Oligochaeta	452	0.338	237	0.0711	4,769	2.5799
TOTAL # ORGANISMS	493		520		4,774	
TOTAL BIOMASS		10.3326		1.4919		2.5799
CORRECTED BIOMASS (+10%)		11.3658		1.6411		2.8379

TABLE 6.3. (Continued)

All values are expressed as #'s per square meter.

	Station #0062		Station #0075		Station #0100	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera						
O. Odonata					15	0.0775
O. Trichoptera					212	0.1177
O. Diptera						
F. Chironomidae	5		1	0.0041	613	0.5653
F. Empididae						
O. Lepidoptera						
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	5				56	0.073
O. Isopoda						
MOLLUSCA						
Class Gastropoda			5	0.0592	666	3.8369
Class Pelecypoda					10	0.0283
PLATYHELMINTHES						
Class Turbellaria					1	0.0036
ANNELIDA						
Class Hirudinea						
Class Oligochaeta	4,396	6.9561	84	0.0062	452	1.9171
TOTAL # ORGANISMS	4,406		90		2,024	
TOTAL BIOMASS		6.9561		0.0695		6.6194
CORRECTED BIOMASS (+10%)		7.6517		0.0765		7.2813

TABLE 6.3. (Continued)

All values are expressed as #'s per square meter.

Station #0085		Station #0102		Station #0072		Station #0070	
Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
		5					
		10					
		56	0.0516				
4	0.0006	102	0.0067			5	
				1	0.0008		
		5					
		194	0.3693			15	
				1	0.00075		
		123	0.7303				
		357	0.2257				
		15	0.0257				
69	0.0162	230	0.1763	3		483	0.1672
73		1,097		5		503	
	0.0168		1.5856		0.00155		0.1672
	0.0185		1.7442		0.0017		0.1839

TABLE 6.4. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - DETROIT RIVER.

SPECIES	STATION NUMBER (#/m²)									
	0104	0101	0103	0062	0075	0100	0085	0102	0072	0070
EPHEMEROPTERA:										
Ephemeridae: Hexagenia limbata	8	107						15		
ODONATA										
Coenagrionidae: sp. indet.								31		
Ishnura sp.						15				
LEPIDOPTERA										
Munroessa sp.								15		
TRICHOPTERA										
Polycentropodidae:										
Polycentropus sp.		4								
Nyctiophylax sp.								15		
Hydroptilidae: Agraylea sp.						582		46		
Hydropsychidae: Hydropsyche sp.	38									
DIPTERA										
Empididae: sp. indet.									4	
Chironomidae:										
Cryptochironomus sp.						31				
Chironomus sp.										15
Chironomus plumosus group		23				107				
Dicrotendipes sp.						15				
Endochironomus sp.	4			15		138				
Paratanytarsus sp.						306		199		
Procladius sp.		31				123	8			
AMPHIPODA										
Talitridae: Hyalella azteca	11					61				
Gammaridae:										
Gammarus fasciatus				15				153		
G. lacustris			15							46
Crangonyx gracilis		4								46
ISOPODA										
Asellidae: Asellus sp.		4							4	
GASTROPODA										
Valvatidae: Valvata sincera					11					
Physidae: Physella gyrina sayi		4								
Planorbidae: Helisoma sp.								46		
Hydrobiidae: Amnicola limosa								123		
PELECYPODA										
Sphaeriidae: Musculium sp.	4									
HIRUDINEA										
Mooreobdella sp.		19								
Helobdella lineata								31		
OLIGOCHAETA										
Enchytraeidae: sp. indet.								15		
Naididae:										
Dero sp.						46		77		
Amphichaeta sp.								77		
Tubificidae:										
Tubifex tubifex			352				4			
Potamothrix vejdovskyi							8			
Spirosperma ferox		4			61		4			
Quistadrilus multisetosus	11		536			15		15		
Limnodrilus hoffmeisteri	96	34	1,777	3,294	31	77	31			77
L. udekemianus				214						107
L. claparedeianus	11		705	214	31	31				77
L. cervix										31
Immatures with capilliform setae								31	4	
Immatures without capilliform setae	153	100	1,241	1,976	92	214	42	92	8	383
Total Number of Organisms	347	395	4,626	5,728	226	1,828	97	981	20	736
Species Diversity (H')	2.30	2.80	2.12	1.39	2.04	3.17	2.00	3.51	1.92	2.13
Species Richness (S.R.)	2.00	2.38	0.70	0.68	0.98	2.22	1.55	2.71	1.36	1.14
Evenness (J')	0.69	0.78	0.82	0.54	0.88	0.81	0.77	0.87	0.96	0.76

7. LAKE HURON

7.1. MIDLAND BAY

Introduction

Midland Bay (Fig. 7.1), in comparison to the areas sampled on the lower Great Lakes, was a relatively uncontaminated area. The major inputs to the bay have been primarily from relatively small local industries, and domestic sources.

Water Quality

Water quality conditions (Table 7.1.1) in Midland Bay revealed an area of only moderately hard water (lower than recorded in Lake Ontario-Section 3) of high pH. Organic content was low at all stations and the waters were generally clear with a low suspended particle load. Salts (Na and Cl) were very low. Results overall were homogeneous and showed little variation among sites (Table 7.1.1).

Sediment Quality

Sediments in Midland Harbour were a sand silt mix in which sand varied from a high of 77% to a low of 10%. Despite this variability, organic content was consistently high. Similarly, contaminant levels were also moderately high and at all stations at least one parameter exceeded M.O.E. guidelines. Solvent extractables, Fe and some of the other metals most consistently exceeded the guidelines though most, with the exception of Fe, were less than 2 times the limits (Table 7.1.2). Pesticide levels were low at all stations and, with minor exceptions were all below detection levels.

Station 512 (Fig. 7.1), located at the mouth of the harbour, was situated in an area of predominantly silt and clay substrate (Table 7.1.2). Organic content was high, and sediment contaminant levels were slightly above M.O.E. guidelines for most parameters. Levels of Cr and Fe were highest, exceeding the guidelines by ca. 3 times in each case.

Station 513 was located in one of the ship docks in the harbour. Sediments here were primarily sand (77%), with a minor amount of silt (17%). Despite the high sand content, organic content was also relatively high, as were levels of contaminants. Solvent extractables were highest of any of the areas sampled and were nearly 2 times M.O.E. guidelines (Table 7.1.2). Of the 8 parameters listed in Table 7.1.2 for which guidelines have been developed, only four exceeded the acceptable levels.

Sediments at station 514, located along the western edge of the harbour, were comprised mainly of silts (52%) and sand (33%) and were moderately high in organic content. Contaminant levels were generally moderate and of the 5 that exceeded the guidelines, most did so by relatively small amounts.

Station 515, located about 200 m east of station 514 was similar in

sediment characterization and levels differed only slightly for all parameters (Tables 7.1.2).

Located in the center of the harbour, station 516 was situated opposite the main dock area (Fig. 7.1). Sediments in this area were mainly a sand-silt mixture (48% : 40%) of moderately low organic content. Sediment contaminant parameters were similar to the other areas of the bay and were in fact slightly lower than at stations 512 and 513. In the case of many of the metals, levels were only half those recorded at these latter two stations.

Sediments at station 517, located about 100 m southeast of station 516, were comprised of a high proportion of sand (67%) and were correspondingly low in organic content. Contaminant levels remained comparable to station 516 despite the higher sand and lower organic content, and Hg and solvent extractables in particular were elevated. The mercury levels were, in fact, the highest in the harbour and were ca. 3 times higher than the guidelines permit.

Station 518 was in an area of mainly sand-gravel substrate (49% and 5%) with a moderate level of silt (35%). Organic content and contaminant levels were, as a result, also moderately high, though only 4 parameters exceeded the guidelines.

Station 519, located at about the middle of the bay, was an area of mainly silty sediments (59%) of moderately high organic content. Contaminant levels were similar to those at stations 514 and 515, both of which were located in the open part of the harbour.

Station 520 was in an area of sandy substrate (63%) with a moderately low silt fraction. Organic content, however, was relatively high, though this was not matched by contaminant levels, which were the lowest of any station sampled.

Station 521, like station 512, was located at the entrance to the bay. Sediments here were mainly silts (63%) with a small percentage of sand (14%) and moderately high in organic content. Contaminant levels were also very similar, though levels of solvent extractables were ca. 30% higher than at station 512.

The harbour appears to be divided into two sedimentary zones. The first (stations 512, 514, 515, 519, and 521) is the central, open-water section of sandy substrate with considerable silt accumulation. Organic content and contaminant levels were generally higher at these stations than at the stations close to shore (the second zone). The exception was solvent extractables.

The second zone was the shoreline area (stations 513, 516, 517, 518 and 520) which consisted of generally sandy substrates. Though contaminant levels were generally lower, the levels of solvent extractables reached their highest values in this zone.

Benthic Invertebrates

Though sediment distribution appeared to follow a pattern in the harbour, no such zonation was apparent in the benthic communities investigated. Rather, these presented the harbour habitat as nearly homogeneous in terms of community structure (Table 7.1.4).

Station 512 (Fig. 7.1), located at the mouth of the harbour, was situated in an area of predominantly silt and clay substrate (Table 7.1.4). The benthic community consisted mainly of sediment fine particle detritivores, which formed 61% of the fauna. The remaining 39% was comprised of predators, such as Procladius and Oecetis, and epibenthic grazers, such as Asellus and Tanytarsus. The relatively low density of organisms overall was likely a result of the high clay content, which would have limited burrowing forms such as the oligochaetes.

Station 513 was located in one of the ship docks in the harbour and sediments here were primarily sand (77%) and low in silt (17%). The benthic fauna differed little from station 512, except for a slightly more diverse fauna, particularly among the oligochaetes (Table 7.1.4.). Sediment fine particle feeders still comprised the major portion of the fauna (66%) and these consisted of the oligochaetes, which were represented by the common sandy substrate species Spirosperma ferox and Quistadrilus multisetosus, and the chironomid Chironomus.

Sediments at station 514, located along the western edge of the harbour were comprised mainly of silts (52%) and sand (33%). The benthic fauna was similar to that found at the preceding two stations and differed only in a slightly increased density. Most of this increase occurred in the Chironomus - oligochaete fine sediment feeding group, which most likely responded to the lower sand content of the sediments.

Station 515, located about 200 m east of station 514, was similar in both sediment characterization and faunal diversity (Tables 7.1.4). Sediment feeders still comprised the major component, though grazers had increased in proportion (42%). Diversity of predators had also increased and included such forms as Sialis, Cryptochironomus, and Procladius.

Located in the center of the harbour, station 516 was situated opposite the main dock area (Fig. 7.1). Sediments in this area were mainly a sand-silt mixture (48% : 40%). The benthic fauna, though reduced in density, was still diverse and included most of the species encountered at the preceding stations.

Sediments at station 517, located about 100 m southeast of station 516, were comprised of a high proportion of sand (67%). The benthic fauna, however, was considerably larger in terms of density, though it showed little change in diversity. Most of the increase took place in the fine sediment feeding community of oligochaetes, clams (Pisidium) and Chironomus spp.

Station 518 was in an area of mainly sand-gravel substrate (49% and

5%) with a moderate level of silt (35%). Benthic diversity was reduced and consisted mainly of a large population of Chironomus thummi group and a few oligochaetes. Sediment type appeared the most likely factor reducing oligochaete density since levels of potential contaminants affecting this group were low.

Station 519, located at about the middle of the bay, was an area of mainly silty sediments (59%) of moderately high organic content. A diverse fauna also existed at this location, comprised mainly of sediment fine particle feeders. A greater proportion of the species were chironomids rather than oligochaetes and indicated coarse organic matter was relatively more significant in this area.

Station 520 was in an area of sandy substrate (63%) with a moderately low silt fraction, though organic content was relatively high. Density and diversity of benthic organisms was highest of any of the stations, though over half of the density was due to a single chironomid species, Chironomus thummi. Epibenthic grazers, such as Hyalella azteca and Asellus were also significantly higher, as were the gastropods, most of which utilize coarse detritus and macrophytes. All of these factors indicated that a large source of detrital material was available at this location. It is therefore likely that this area of the bay was one of the main depositional areas for coarse organic matter, since this high density did not occur at any of the other stations.

Station 521, like station 512, was located at the entrance to the bay, in a similarly silty (63%) area. Faunal density and diversity were also similar and the benthos consisted primarily of fine particle feeders, of which chironomids and oligochaetes comprised 90% of the fauna.

In summary, conditions in the harbour appeared to vary slightly among stations in terms of sediment contaminant levels and substrate organic content. Benthic communities also differed only slightly among stations, usually only in density of organisms. While the fine particle feeding community, comprised usually of Chironomus spp., the oligochaetes, and the Pisidium spp. dominated the fauna at all stations, species composition lacked the community typical of organically polluted areas. For the most part, the oligochaete community was quite diverse and did not dominate the fauna numerically, as would have been expected in organically polluted conditions.

Throughout the harbour, the benthic fauna showed a variation in density most likely attributable to microhabitat differences. These changes were not likely the result of any gross changes in either the physical or chemical nature of their habitats.

In general, the harbour can be classified as eutrophic (i.e., productive), but did not appear to be organically polluted. Contaminant levels appeared to have little effect on the benthos, whose main determining factors appeared to be organic content, specifically the local availability of detrital matter.

Summary

1) Conditions in Midland Harbour were typical of shallow, eutrophic, near-shore areas. Sediments were primarily fine organic matter and sand. Sediment type and organic content appeared to be the main factors affecting the benthic community.

2) Contaminant levels, while in some cases exceeding guidelines, were generally low and appeared to have no effect on the benthos.

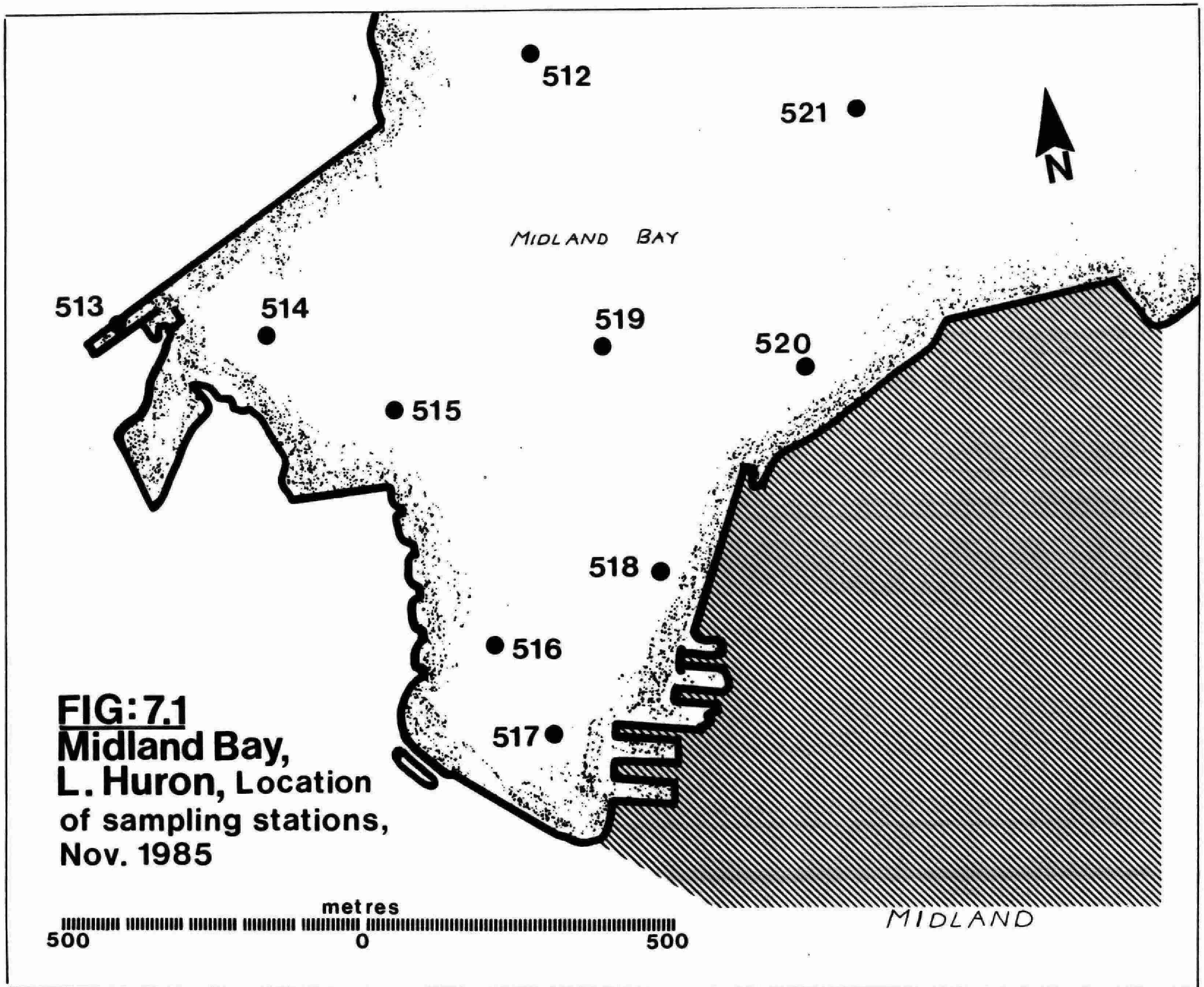

FIG: 7.1
Midland Bay, L. Huron, Location of sampling stations, Nov. 1985

TABLE 7.1.1. WATER QUALITY DATA - MIDLAND HARBOUR. (TAKEN 1 M OFF BOTTOM).

Station Number	pH	Hardness (mg/l)	Chemical Oxygen Demand (COD) (mg/l)	Dissolved Organic Carbon (DOC) (mg/l)	Total Kjeldahl Nitrogen (TKN) (mg/l)	Turbidity	Suspended Particulate (mg/l)	Sodium (Na) (mg/l)	Chloride (Cl) (mg/l)
512	8.20	80.0	17.2	4.0	0.34	4.8	3.88	5.58	9.45
513	8.21	82.0	13.3	3.8	0.33	5.3	5.02	5.74	9.60
514	8.21	84.0	15.5	3.8	0.28	3.7	2.95	5.46	9.25
515	8.23	81.5	13.5	3.9	0.29	5.3	3.66	5.45	9.30
516	8.23	80.0	16.1	3.9	0.35	5.4	5.10	5.80	9.85
517	8.17	83.5	15.4	4.0	0.39	5.6	3.78	5.87	10.05
518	8.19	79.5	15.7	3.9	0.34	5.1	3.80	5.65	9.70
519	8.20	82.0	16.4	3.9	0.31	4.7	8.56	5.50	9.30
520	8.15	83.0	14.1	3.9	0.36	4.5	2.55	5.59	9.45
521	8.24	80.5	12.4	3.8	0.33	5.7	2.47	5.57	9.25

TABLE 7.1.2. SEDIMENT DATA - MIDLAND HARBOUR.

Station Number	Grain Size (%) Gravel/Sand/Silt/Clay	Total Organic Carbon (TOC) (mg/g)	Loss on Ignition (LOI) (%)	Total Phosphorus (TP) (mg/g)	Total Kjeldahl Nitrogen (TKN) (mg/g)	Solvent Extractables (ug/g)
512	0/10/66/23	47.0	8.9	1.06	3.3	1,979.0
513	1/77/17/3	32.0	7.8	0.72	0.6	2,891.0
514	0/33/53/10	36.0	5.9	0.95	1.9	1,784.0
515	0/35/53/10	37.0	6.3	0.91	1.2	1,772.0
516	0/49/40/8	25.0	3.6	0.72	0.7	1,570.0
517	1/67/24/5	18.0	2.3	0.88	0.5	2,436.0
518	5/50/36/7	21.0	3.8	0.52	0.6	1,005.0
529	0/25/60/10	36.0	6.7	0.82	1.9	1,965.0
520	3/63/26/5	48.0	7.3	0.94	1.0	903.0
521	0/14/63/20	43.0	7.7	1.06	2.5	2,797.0

Station Number	Cu (ug/g)	Cr (ug/g)	Hg (ug/g)	Fe (ug/g)	As (ug/g)	Zn (ug/g)	Al (ug/g)	Total PCB's (ug/kg)
512	42.0	74.0	0.20	36,000.0	4.97	160.0	23,000.0	< 20
513	44.0	20.0	0.07	34,000.0	3.52	110.0	5,900.0	< 20
514	34.0	34.0	0.11	24,000.0	2.85	120.0	13,000.0	< 20
515	29.0	36.0	0.14	22,000.0	3.05	120.0	13,000.0	< 20
516	24.0	27.0	0.11	17,000.0	2.20	77.0	10,000.0	20
517	31.0	19.0	1.00	14,000.0	1.45	86.0	7,600.0	< 20
518	66.0	23.0	0.35	17,000.0	2.20	110.0	8,200.0	< 20
519	32.0	46.0	0.18	26,000.0	3.45	120.0	16,000.0	20
520	15.0	20.0	0.05	18,000.0	3.80	60.0	7,400.0	< 20
521	43.0	65.0	0.18	33,000.0	4.34	160.0	20,000.0	50

TABLE 7.1.3. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA - MIDLAND BAY.

All values are expressed as #'s per square meter.

	Station #512		Station #513		Station #514	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Odonata			1			
O. Trichoptera	1		4		4	
O. Diptera						
F. Chironomidae	239	0.5009	788	0.4716	637	0.9591
F. Chaoboridae	16	0.0171			3	
F. Ceratopogonidae			3			
O. Megaloptera						
Class Arachnida						
O. Acarina						
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda			108	0.2658		
O. Isopoda	20	0.0674	56	0.5259		
MOLLUSCA						
Class Gastropoda			14	0.0881	1	
Class Pelecypoda	81	0.0666	106	0.2072	89	0.1173
ANNELIDA						
Class Oligochaeta	389	0.1931	431	0.275	322	0.1981
TOTAL # ORGANISMS	746		1,511		1,056	
TOTAL BIOMASS		0.8451		1.8336		1.2745
CORRECTED BIOMASS (+10%)		0.9296		2.0170		1.4019

TABLE 7.1.3. (Continued)

All values are expressed as #'s per square meter.

	Station #515		Station #516		Station #517	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Odonata						
O. Trichoptera	4	0.0054	5	0.0046		
O. Diptera						
F. Chironomidae	513	0.6339	166	0.1867	751	0.5058
F. Chaoboridae	8	0.0033	9	0.0044	36	0.0036
F. Ceratopogonidae						
O. Megaloptera	1					
Class Arachnida						
O. Acarina						
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	28	0.0149	4	0.0003	41}	0.1604
O. Isopoda	25	0.1404	4	0.0076	25}	
MOLLUSCA						
Class Gastropoda	13	0.1373	1		51	0.6206
Class Pelecypoda	61	0.0585	22	0.0442	301	0.1332
ANNELIDA						
Class Oligochaeta	204	0.3013	281	0.1143	1,675	0.7266
TOTAL # ORGANISMS	1,383		492		2,880	
TOTAL BIOMASS		1.295		0.3621		2.1502
CORRECTED BIOMASS (+10%)		1.425		0.3983		2.352

TABLE 7.1.3. (Continued)

All values are expressed as #'s per square meter.

Station #518		Station #519		Station #520		Station #521	
Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
20	0.048			51	0.0076		
610	0.3435	378	0.5272	4,719	3.430	285	0.3413
		19	0.0282			20	0.0027
				41	0.0336	1	
		8	0.0012	725	0.4580		
		6	0.0084	306	1.5472	1	
8	0.0477	1	0.0576	378	1.8356		
		89	0.0602	306	0.6496	42	0.0673
69	0.0038	147	0.1073	490	0.1976	472	0.1218
699		648		7,016		821	
	0.443		0.7901		8.1592		0.5331
	0.4873		0.8691		8.9751		0.5864

TABLE 7.1.4. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - MIDLAND BAY.

SPECIES	STATION NUMBER (#/m²) 512	513	514	515	516	517	518	519	520	521
MEGALOPTERA										
Sialidae: Sialis sp.				4						
ODONATA										
Coenagrionidae: Enallagma sp.		4								
TRICHOPTERA										
Leptoceridae: Oecetis sp.	4			8						
Hydropsychidae: Hydropsyche sp.									31	
Polycentropodidae:										
Phylocentropus sp.		11	11				46		61	
DIPTERA										
Ceratopogonidae:										
Palpomyia complex	15									
Chaoboridae:										
Chaoborus punctipennis			11	8	4	77		8		23
Chironomidae:										
Cryptochironomus sp.	23	31	46	46	31			23	245	
Chironomus plumosus group	42							8		295
Chironomus thummi group	4	199	417	88	42	904	797	84	4,627	
Dicrotendipes sp.								4		
Glyptotendipes (Phytotendipes)									245	
Phaenopsectra sp.									153	
Tanytarsus sp.	115	153	149	218	11			130	92	
Psectrocladius (P.) sp.				4				4		
Procladius sp.	77	65	19	50	69	61	77	149	337	19
AMPHIPODA										
Talitridae: Hyalella azteca					8				827	
Gammaridae:										
Gammarus lacustris				23		31		19		
G. pseudolimnaeus		80								
ISOPODA										
Asellidae: Asellus sp.	34			23		31		11	337	4
PELECYPODA										
Sphaeriidae:										
Sphaerium striatinum						31				11
Pisidium sp.										27
P. casertanum	88		111	69	15	368			460	15
P. lilljeborgi		73		8				145		
GASTROPODA										
Valvatidae:										
Valvata sincera		4	4	4		15	15		31	
V. tricarinata					4				61	
Hydrobiidae: Amnicola limosa									306	
Physidae: Physella gyrina sayi						15			61	
Planorbidae: Gyralus parvus									31	
OLIGOCHAETA										
Tubificidae:										
Spirosperma ferox		19							31	
Quistadrilus multisetosus		57	57	31			15		31	
Isochaetides freyi	19			11				11		
Limnodrilus hoffmeisteri		19	57	11	23	169		23	61	69
Immatures with capilliform setae					11			19		69
Immatures without capilliform setae	268	195	310	107	207	1,670	77	96	306	337
Total Number of Organisms	689	910	1,192	663	425	3,372	1,027	730	7,920	919
Species Diversity (H')	2.67	3.06	2.58	3.20	2.44	2.06	1.22	3.10	2.59	2.22
Species Richness (S.R.)	1.93	2.19	1.74	3.06	2.12	1.47	0.89	2.66	2.47	1.64
Evenness (J')	0.77	0.82	0.74	0.78	0.70	0.59	0.47	0.79	0.60	0.67

7.2. PENETANG HARBOUR

Introduction

Penetang Harbour, similar to nearby Midland Bay, was a relatively unimpacted area. Small local industries and domestic sources represented the only major impacts in this area.

Water Quality

Penetang Harbour was an area of moderately hard water and relatively high pH (Table 7.2.1). Organic content was low at most stations and turbidity and suspended particle load were low except at station 528.

Sediment Quality

Sediments in Penetang Harbour were highly variable, ranging from mainly silt (75%) and clay (14%) in the South Basin, to mainly sand (90%) in the constricted central section (Fig. 7.2). Organic content and contaminant levels varied accordingly, being generally low in areas of sand substrate (Table 7.2.2). Pesticide levels were generally below detection levels with the exception of station 527 (dieldrin 4 ng/g) and station 528 (heptachlor epoxide 10 ng/g).

Station 522, located in the shallow south basin, was situated in a predominantly silty area of high organic content. Contaminant levels were the highest recorded in the harbour for Cu, Cr, Zn and solvent extractables, all of which exceeded guidelines by 2 -3 times (Table 7.2.2).

Station 523 was also located in the South Basin in shallow water along the Penetanguishene waterfront. Sediment composition was very similar to station 522, though organic content was slightly reduced, as were contaminant levels.

Located at the north end of the south basin, station 524 was in a sand-silt substrate of moderate organic content. Contaminant levels were similar to those at the preceding stations.

Approximately 700 m north of station 524, sediments at station 525 were sand and silt (31% : 55%) similar to station 524, and were generally moderate in organic content (Table 7.2.2). Contaminant levels were low for all parameters and only two (Cr and Fe) exceeded M.O.E. guidelines.

Station 526 was located in a narrow section of the bay, high in sand (87%) and very low in organic matter. Contaminant levels were very low, consistent with sandy areas and all were well below M.O.E. guidelines. The very low organic content, as well as the mainly sand substrate, indicated this was an erosional area with little or no deposition or retention of organic matter.

Station 527 was also located in a sandy area (89%), though organic

content was higher than at station 526, indicating the accumulation of at least some organic matter had occurred. Contaminant levels were similarly low and all were below guidelines.

Located in a small bay in the north basin, station 528 was in an area of predominantly silty substrates, moderately high in organic content, though generally low in contaminant levels (only Cr and Fe again exceeded M.O.E. guidelines).

Similar situations occurred at stations 529 and 530, both of which were in areas of high silt content with moderately high organic levels. Contaminant levels were similar to those in soft sediment in the south basin, though levels of Fe were approximately 30% higher.

Station 531, located in the outer harbour, was an area of sandy substrate (85%) low in organic matter. Contaminant levels were very low, and in many cases, levels of individual parameters were lower than at stations 526 and 527.

It was apparent, therefore, that most of the contaminants were distributed generally throughout the sediments in the harbour and that only in areas where sorptive capacities were low (sandy substrates) were levels reduced to generally insignificant amounts.

Benthic Invertebrates

The distribution of benthic organisms in the harbour appeared to closely follow the distribution of organic sediments. Densities of organisms were generally highest in silty areas, though diversity was often higher in the sandy sections, reflecting the tendency of a few species to dominate the fauna in the soft sediment areas.

Station 522, located in the shallow south basin, was situated in a predominantly silty area of relatively high organic content. Not surprisingly, the benthic fauna consisted mainly of fine sediment feeders, primarily the chironomids Dicrotendipes, Parachironomus, Saetheria, and Tanytarsus, the snail Valvata and a small population of oligochaetes. One species alone, the chironomid Tanytarsus, made up 55% of the total fauna. The epibenthic grazers such as Hyalella azteca and Endochironomus, and the predators (Cryptochironomus and Procladius) comprised the remainder (23% and 3.5% respectively). The rather diverse chironomid fauna, coupled with a low density of oligochaetes, indicated this area was eutrophic but not organically polluted.

Station 523 was also located in the South Basin in shallow water along the Penetanguishene waterfront. Sediment composition was very similar to station 522 though organic content was slightly reduced, as were contaminant levels. The benthic fauna was also similar to station 522 but differed in a much lower density and a somewhat reduced diversity. The main constituents of the fauna, however, were the same, and the chironomid Tanytarsus was still the most common organism, comprising 81% of the fauna. Oligochaetes formed only a small percentage of the total fauna, despite the

high organic content, with the majority of the fine sediment feeders and in fact the majority of the entire fauna comprised of chironomid species.

Station 524 was located at the north end of the south basin in a sand-silt substrate of moderate organic content. The benthic fauna, though reduced in density, was moderately diverse. Most of the fauna consisted of oligochaetes (65%) and fine sediment feeders comprised 73% of the benthos. The high diversity of oligochaete species however indicated that eutrophic conditions and not organic pollution prevailed in the sediments.

Station 525 was situated in shallow water approximately 700 m north of station 524. Sediments were sand and silt (31% : 55%) and, as at stations 522 and 523, located in similarly shallow areas close to shore, the benthic fauna consisted mainly of chironomids, especially the fine particle grazers such as Tanytarsus and Glyptotendipes. Sediment infauna (oligochaetes) comprised 10% while fine particle feeders comprised 72% in total. Epibenthic grazers (amphipods and isopods) comprised 18% while predators made up the remaining 10%. Conditions here appeared eutrophic (as are most soft substrate littoral areas) but not organically polluted.

Station 526 was located in a narrow section of the bay high in sand (87%) and very low in organic matter. The very low organic content, as well as the mainly sand substrate, indicated this was an erosional area with little or no deposition or retention of organic matter. The low density of benthic organisms appeared to be a consequence of the substrate type. The species present (Table 7.2.4) were mainly fine sediment feeders, though even these reflected the sandy sediments, since the most common species was Quistadrilus multisetosus, typical of sandy habitats.

Station 527 was also located in a sandy area (89%), though organic content was higher than at station 526, indicating the accumulation of at least some organic matter had occurred. As a result, faunal density and diversity were also much higher and fine sediment feeders formed the major part of the benthic community (78%). While oligochaetes comprised 70% of this fraction (54% of the total fauna), the species Q. multisetosus was again the most common, a consequence of the sandy substrate. Chironomids were the most varied group and represented all three groups (fine sediment and coarse detrital feeders and predators).

Located in a small bay in the north basin, station 528 was in an area of predominantly silty substrates, moderately high in organic content, though generally low in contaminant levels (moderate levels of the pesticide heptachlor epoxide were recorded (M.O.E. unpublished data)). The fauna was reduced in density though diversity remained high and this may be a result of the presence of this pesticide. The chironomid fauna again dominated the benthic fauna both in density and diversity, and consisted primarily of fine particle feeders (49%) and predators such as Cryptochironomus and Procladius (29%). Epibenthic grazers comprised only 22% of the total and indicated a general lack of coarse detrital material.

Similar situations occurred at stations 529 and 530, both of which were in areas of high silt content with moderately high organic levels. At

both, chironomids were the major components of the fauna, while the oligochaetes made up the next largest fraction. At all three stations the sediment fine particle feeders comprised the major part of the fauna, a result consistent with the high silt content in these areas.

Station 531, located in the outer harbour, yielded a very diverse fauna, high in density of organisms (Table 7.2.2). A sandy area, low in organic matter, it nevertheless appeared to be an area of accumulating detritus, likely coarse material. This was indicated by the presence of the trichopteran species, the chironomid Endochironomus and the large populations of Gammarus pseudolimnaeus and Amnicola limosa. All of these organisms are associated with coarse detritus, particularly decomposing plant matter. Sediment infauna was a relatively minor component and again was represented by the typical sandy substrate species Quistadrilus multisetosus.

In summary, the benthic community in Penetang Harbour appeared to be determined primarily by depth and sediment type. Shallow silty areas tended to be the most productive and the fauna in these areas (stations 522, 523, 524, 525, 528, 529, and 530) was comprised mainly of sediment fine particle feeders, of which the chironomid species were the most common and diverse components. Oligochaetes played only a minor role in benthic composition, mainly as a result of the sediment type. These areas all appeared to be eutrophic (or productive, littoral areas) but bore no evidence of being organically polluted.

Deeper, sandy areas (stations 526, 527, and 531) were the least productive, except where coarse detritus had accumulated, resulting in a diverse, though quite characteristic fauna at these stations (527 and 531).

Contaminant levels were low at all stations and even the highest levels (station 522) appeared to have no effect on the benthic fauna. Though pesticides were present at stations 527 and 528, these levels were very low. The changes in the benthic fauna at these stations were slight and could not positively be attributed to these contaminants. The differences in density appear rather, as merely microhabitat effects.

Summary

1) Sediment type and depth were the main factors effecting the benthic community. Shallow, eutrophic areas, high in silt content, were the most productive and were comprised of fine sediment feeding organisms.

2) Deeper water areas of sandy substrate (stations 526, 527, and 531) were low in both density and diversity of organisms. Where sands appeared to be overlain, or to include, coarse organic matter (stations 527 and 531), diversity was high, and a characteristic fauna of mainly sediment surface feeders occurred.

3) Contaminant levels were low at all areas and had no apparent effect on the benthic fauna.

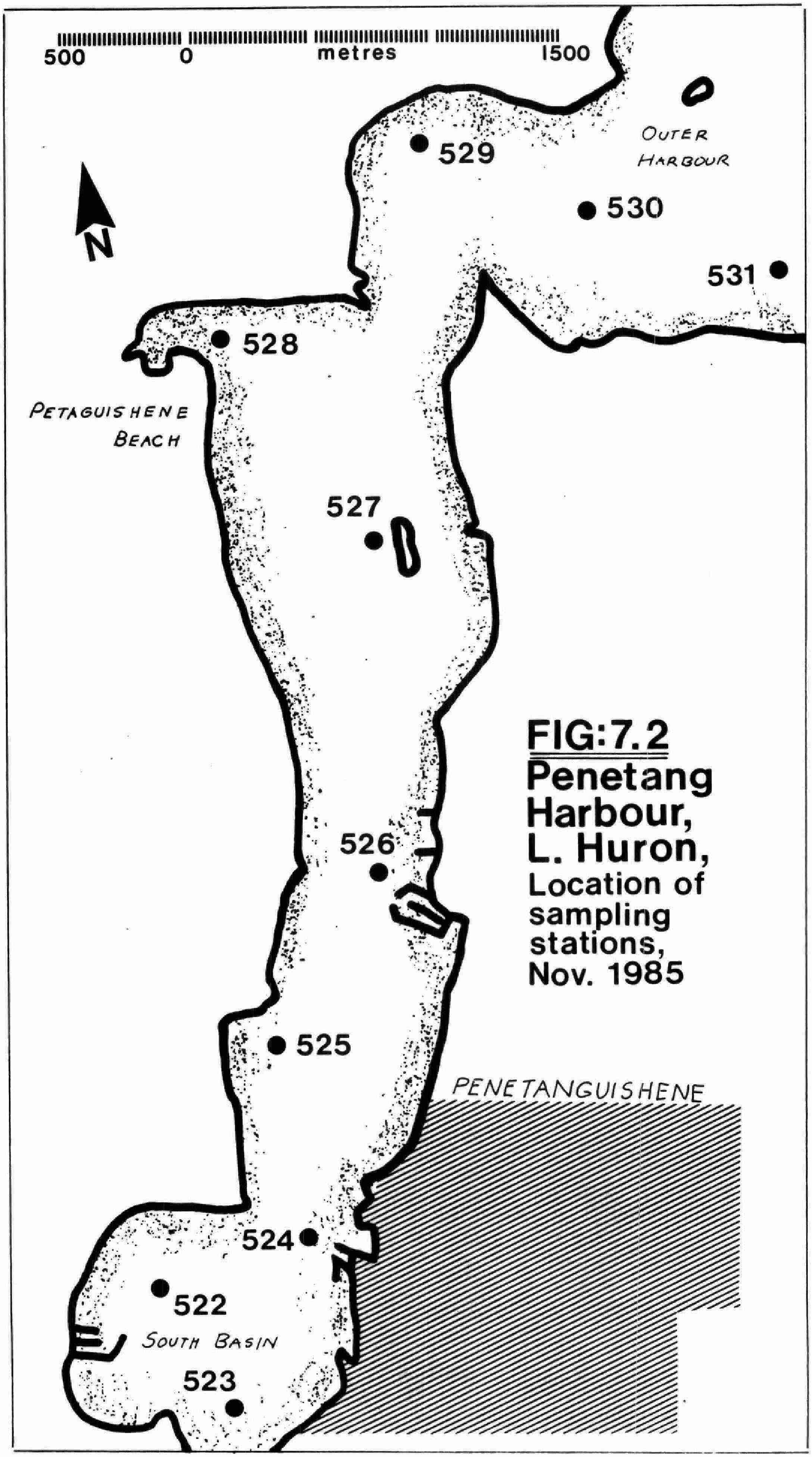

FIG:7.2
Penetang Harbour, L. Huron,
Location of sampling stations, Nov. 1985

TABLE 7.2.1. WATER QUALITY DATA - PENETANG HARBOUR (TAKEN 1 M OFF BOTTOM).

Station Number	pH	Hardness (mg/l)	Chemical Oxygen Demand (COD) (mg/l)	Dissolved Organic Carbon (DOC) (mg/l)	Total Kjeldahl Nitrogen (TKN) (mg/l)	Turbidity	Suspended Particulate (mg/l)	Sodium (Na) (mg/l)	Chloride (Cl) (mg/l)
522	8.18	88.0	14.6	3.0	0.50	8.2	6.24	5.00	7.23
523	8.16	87.0	17.0	3.0	0.39	9.8	6.85	5.04	7.19
524	8.50	92.0	14.6	3.1	0.43	6.5	8.16	5.18	7.37
525	8.21	85.5	11.7	3.0	0.34	7.3	4.71	4.92	7.22
526	8.19	84.5	25.3	3.1	0.73	6.4	76.15	4.88	7.25
527	8.19	84.5	11.7	3.1	0.32	5.9	3.12	4.81	7.30
528	8.19	83.5	22.6	3.1	0.49	13.7	67.61	4.76	7.23
529	8.23	76.5	14.6	3.2	0.33	5.6	14.74	4.65	7.32
530	8.19	80.0	15.3	3.2	0.31	5.4	12.42	4.76	7.36
531	8.17	78.0	13.1	3.2	0.29	3.0	4.52	4.63	7.24

TABLE 7.2.2. SEDIMENT DATA - PENETANG HAROUR.

Station Number	Grain Size (%) Gravel/Sand/Silt/Clay	Total Organic Carbon (TOC) (mg/g)	Loss on Ignition (LOI) (%)	Total Phosphorus (TP) (mg/g)	Total Kjeldahl Nitrogen (TKN) (mg/g)	Solvent Extractables (ug/g)
522	0/10/75/14	88.0	16.0	0.98	6.9	3,483.0
523	0/15/72/12	70.0	12.0	0.97	4.7	2,643.0
524	0/35/54/9	41.0	7.4	0.99	2.0	1,493.0
525	0/32/55/8	33.0	6.2	0.77	1.9	791.0
526	1/87/8/2	< 5.0	0.1	0.32	0.2	115.0
527	0/90/7/2	5.8	1.0	0.65	0.3	225.0
528	0/29/58/12	36.0	6.5	0.79	2.5	1,010.0
529	0/16/63/20	51.0	9.7	0.68	3.6	2,038.0
530	0/10/64/26	54.0	10.0	1.14	4.3	2,246.0
531	0/85/12/2	< 5.0	0.4	0.51	0.2	144.0

Station Number	Cu (ug/g)	Cr (ug/g)	Hg (ug/g)	Fe (ug/g)	As (ug/g)	Zn (ug/g)	Al (ug/g)	Total PCB's (ug/kg)
522	49.0	85.0	0.24	26,000.0	4.13	200.0	18,000.0	25
523	33.0	52.0	0.14	24,000.0	2.92	120.0	17,000.0	30
524	33.0	35.0	0.10	18,000.0	2.98	130.0	11,000.0	120
525	15.0	28.0	0.04	15,000.0	2.52	53.0	11,000.0	< 20
526	3.7	9.0	< 0.01	6,800.0	0.60	13.0	2,300.0	< 20
527	3.3	10.0	0.01	6,300.0	0.65	22.0	3,000.0	< 20
528	23.0	50.0	0.09	21,000.0	4.00	89.0	13,000.0	< 20
529	35.0	64.0	0.13	32,000.0	6.11	150.0	21,000.0	< 20
530	42.0	63.0	0.12	38,000.0	6.76	180.0	25,000.0	< 20
531	3.0	4.1	< 0.01	4,800.0	0.46	9.4	1,600.0	< 20

TABLE 7.2.3. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA - PENETANG HARBOUR.

All values are expressed as #'s per square meter.

	Station #522		Station #523		Station #524	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera						
O. Odonata						
O. Trichoptera					5	
O. Coleoptera						
O. Diptera						
F. Chironomidae	3,432	1.7428	1,481	0.4716	64	0.2294
F. Chaoboridae						
F. Ceratopogonidae	18	0.0073	3		3	0.0039
O. Megaloptera			1	0.0444		
Class Arachnida						
O. Acarina	29	0.0088				
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	554	0.2417	36	0.0209	61	0.0050
O. Isopoda	50	0.6159	13	0.0261	5	
MOLLUSCA						
Class Gastropoda	157	0.1302			1	
Class Pelecypoda	31	0.0138	9	0.0567		
NEMATODA						
PLATYHELMINTHES						
Class Turbellaria	42	0.0019				
ANNELIDA						
Class Hirudinea	5					
Class Oligochaeta	55	0.1025	54	0.0772	590	0.5565
TOTAL # ORGANISMS	4,231		1,597		729	
TOTAL BIOMASS		2.8649		0.6969		0.7948
CORRECTED BIOMASS (+10%)		3.1514		0.7666		0.8743

TABLE 7.2.3. (Continued)

All values are expressed as #'s per square meter.

	Station #525		Station #526		Station #527	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera					12	0.0008
O. Odonata						
O. Trichoptera					1	0.0027
O. Coleoptera					1	
O. Diptera						
F. Chironomidae	1,318	0.2454	1	0.0007	315	0.0976
F. Chaoboridae			1		1	0.0002
F. Ceratopogonidae						
F. Megaloptera						
Class Arachnida						
O. Acarina	31	0.0168			6	0.0032
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	112	0.0276	8	0.0136	38	0.0064
O. Isopoda	72	0.0658	8	0.00135	158	0.1633
MOLLUSCA						
Class Gastropoda	20	0.0334	17	0.0645	55	0.4937
(one large clam)						(275.19)
Class Pelecypoda	25	0.0134	8	0.0318	45	0.0337
NEMATODA						
PLATYHELMINTHES						
Class Turbellaria						
ANNELIDA						
Class Hirudinea			1			
Class Oligochaeta	148	0.1398	147	0.0332	760	0.6792
TOTAL # ORGANISMS	1,726		191		1,392	
TOTAL BIOMASS		0.5422		0.4439		1.4808 (276.67)
CORRECTED BIOMASS (+10%)		0.5964		0.4883		1.6289 (304.34)

TABLE 7.2.3. (Continued)

All values are expressed as #'s per square meter.

Station #528		Station #529		Station #530		Station #531	
Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
						1	
						19	0.0822
297	0.2063	151	0.1367	121	0.3696	1,134	0.7722
5	0.0012	8	0.0018	5	0.0008		
5	0.1126	5	0.26				
		5	0.0023			19	0.0111
153	0.4862	1		1		213	0.2350
34	0.6342	3	0.003	11	0.0332		
10	0.1601	5	0.0677	6	0.0107	207	1.6577
144	0.0993	65	0.1049	41	0.01899	36	0.1350
				1		3	
17	0.0149					4	0.0010
						6	
120	0.0415	91	0.027	161	0.0877	438	0.4543
785		334		347		2,080	
	1.7563		0.6034		0.5210		3.3485
	1.9319		0.6637		0.5731		3.6834

TABLE 7.2.4. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - PENETANG HARBOUR.

SPECIES	STATION NUMBER (#/m²) 522	523	524	525	526	527	528	529	530	531
EPHEMEROPTERA:										
Ephemeridae:										
Hexagenia sp.						11				
MEGALOPTERA										
Sialidae:										
Sialis sp.							4			
ODONATA										
Coenagrionidae:										
Enallagma sp.										4
TRICHOPTERA										
Leptoceridae:										
Oecetis sp.										4
Mystacides sepulchralis										11
Polycentropodidae:										
Polycentropus sp.			15							
DIPTERA										
Ceratopogonidae:										
Palpomyia complex	46	8								
Chaoboridae:										
Chaoborus punctipennis							8	11	11	
Chironomidae:										
Cryptochironomus sp.	153	50		46		38	119	11	11	402
Chironomus plumosus group	15						4		84	
Chironomus thummi group			19	15						
Demicryptochironomus sp.										8
Dicrotendipes sp.	214		15			19		4		276
Glyptotendipes sp.	77	73		245						
Endochironomus sp.	291		8	77			38			
Phaenopsectra sp.										130
Polypedilum (P.) sp.						4				
Parachironomus sp.	153									
Saetheria sp.	521									
Stictochironomus sp.										4
Cladotanytarsus sp.						111	73			
Tanytarsus sp.	3,845	1,275	31	889		134		31	19	69
Potthastia longimana						11				4
Procladius sp.	77	54		92	4	61	92	80	31	61
AMPHIPODA										
Haustoridae:										
Pontoporeia hoyi									4	
Talitridae:										
Hyalella azteca	980				4			4		
Gammaridae:										
Gammarus lacustris	199		168			31	77			
G. pseudolimnaeus		50		245						203
ISOPODA										
Asellidae: Asellus sp.	92	19		107	19	157	46	4	11	
PELECYPODA										
Sphaeriidae:										
Sphaerium striatinum						80	11	16		
Pisidium casertanum	77			31			142	69	50	38
P. lilljeborgi					8					
GASTROPODA										
Valvatidae:										
Valvata sincera	352				23			4		
V. tricarinata						4			15	54
Hydrobiidae:										
Amnicola limosa	46			31		19	11			226
Physidae:										
Physella gyrina sayi			4							
Planorbidae:										
Helisoma sp.										4
Viviparidae:										
Viviparus sp.					8					
Campeloma descisum						8				

TABLE 7.2.2. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - PENETANG HARBOUR (Continued)

SPECIES	STATION NUMBER (#/m²)									
	522	523	524	525	526	527	528	529	530	531
HIRUDINEA										
Helobdella stagnalis	15									
OLIGOCHAETA										
Tubificidae:										
Quistadrilus multisetosus					138	544				276
Tubifex tubifex			23							
Isochaetides freyi			73	31					11	
Potamothrix moldaviensis			23							
Limnodrilus hoffmeisteri		11	23	61		103	15	23	34	
L. angustipenis			23							
Immatures with capilliform setae		15	73					8		
Immatures without capilliform setae	46	27	245	107		168	84	69	92	15
Naididae:										
Dero sp.	31						8			46
Ophidonais sp.	31									
Total Number of Organisms	6,991	1,582	743	1,977	204	1,503	732	337	373	1,835
Species Diversity (H')	2.60	1.26	3.04	2.72	1.63	3.09	3.34	2.99	3.07	3.27
Species Richness (S.R.)	2.52	1.50	2.65	1.92	1.51	2.68	2.85	2.68	2.40	2.92
Evenness (J')	0.60	0.38	0.78	0.73	0.58	0.75	0.83	0.81	0.85	0.77

8. ST. MARYS RIVER

Introduction

The St. Marys River at Sault Ste. Marie receives a number of influent streams from major industrial users. Algoma Steel, Domtar, and St. Marys Pulp and Paper all have major operations located along the north shore, which have discharged variously treated effluent into the river. In addition, discharges of domestic effluent have in the past, and continue to be of concern. The I.J.C., primarily because of these industrial uses, has listed the river as one of its 42 Areas of Concern in the Great Lakes and as one of the 38 areas where contaminated sediments continue to be a problem (I.J.C. 1987).

Water Quality

St. Marys River (Fig. 8.1) was characterized as borderline hard water of moderately high pH. Organic content of the water was low and the water was clear at most areas (turbidity and suspended particle load were low) (Table 8.1).

Sediment Quality

Sediments in the St. Marys River ranged from mainly sand substrates in the main channel of the river (stations 0078, 0051, 0050, 0075, and 0044), to sand silt mixtures in the more protected areas of lower current (0049, 0048, 0047), to primarily silt in the protected bays on the river (stations 0046 and 0045). Organic levels were similarly distributed, being low at the sandy areas and very high at the predominantly silty areas. Contaminant levels were low upstream in all substrate types and increased dramatically downstream, remaining high despite variations in substrate organic content.

Sediment data for station 0078 indicated this was an area of mainly sandy substrate. Though grain size data were lacking (Table 8.2), this was inferred from the organic content and low contaminant levels, which were present in similarly low levels at the sandy stations 0050 and 0044. Contaminant levels were also very low and in all cases were well below M.O.E. guidelines. It seems reasonable to assume that levels here were indicative of general background levels for the river as a whole.

Station 0051 appeared to be located in a mainly sandy area, though grain size data were lacking for this station as well. The relatively low levels of sediment organic matter suggest that sand formed most of the substrate in this area. Contaminant levels were low as well, many being lower than levels at the preceding station.

Station 0050, also an area of mainly sandy substrate, was similarly low in sediment organic matter and contaminant levels, and levels were directly comparable with those at stations 0078 and 0051.

Station 0049 was located in a bay at the west end of Sault Ste. Marie,

near the Algoma Steel mill. Sediments were mainly sand (52%) with some silt and clay (27% and 17% respectively). Organic content was high and contaminant levels were higher as well, though on average not significantly so, and only 4 of the 8 parameters in Table 8.2 for which guidelines were available exceeded these limits. Zn and Fe however, increased dramatically in this area to 5.8 and 6.7 times the limits respectively. Pesticide levels were generally below detection limits at this, and, in fact, all stations.

Station 0048, located along the Sault Ste. Marie waterfront had very similar physical sediment characteristics. Organic content was very high though this may have been a consequence of the high levels of solvent extractables in the sediments. Levels of other contaminants, in particular, the metals were also elevated. Levels of these however, have been higher in some of the other areas in the Great Lakes (see Sections 3 and 5) though those all occurred in areas of much harder water.

Station 0075 was characterized by a substrate lower in organic content and moderate in contaminant levels. Presumably, on the basis of both organic content and comparison to stations 0049 and 0048, the silt content would have been relatively low (grain size data were lacking) and sand would have been the major constituent of the sediments. While contaminant levels were lower than at the preceding two stations, levels of 5 of the 8 parameters exceeded M.O.E. guidelines.

Station 0047 was also a mixed substrate of sand and silt (43% : 50%) of high organic content and high contaminant levels. Levels of solvent extractables were also high and this may have affected the sediment organic content (Table 8.2).

Station 0046, also high in silt content (62% silt : 30% sand) was relatively low in both organic content and most contaminant levels. The low levels of solvent extractables may have resulted in levels of organic matter being lower than those recorded at the preceding stations, even though those had a lower silt content.

Station 0044 was situated in an erosional area high in sand (95%). Organic content and contaminant levels were low, and compared well with similar areas upstream (station 0078 and 0050).

Station 0045 was in an area high in silt (69%) and, like station 0046, in a depositional area. Sediment organic content was moderately high and contaminant levels, especially of solvent extractables, were also high.

Benthic Invertebrates

Patterns of benthic distribution appeared to be controlled primarily by sediment type and organic content. There were also indications that other factors were influencing the benthic community, especially at those stations along the Sault Ste. Marie waterfront.

Sandy sediments were inferred to predominate at station 0078 from the

organic content which, was low and compared well to levels at the sandy stations 0050 and 0044. Despite the low sediment organic content, the benthic fauna was one of the most diverse and dense of any of the stations sampled. Fine particulate sediment feeders formed only 8% of the fauna, while the largest fraction (72%) was comprised of those species associated with coarse detritus (usually decaying macrophytes) such as Lirceus lineatus, Asellus, Endochironomus, or those species associated with macrophytes such as Polypedilum and Amnicola limosa.

Station 0051 appeared to be located in a mainly sandy area, though grain size data were lacking for this station as well. The relatively low level of sediment organic matter suggests that sand formed most of the substrate in this area. The coarse detritus and macrophytes that were present at the previous station appeared to be lacking, since the very large densities of those species associated with these types of organic accumulations were lacking entirely (Table 8.2). Overall, density was much lower than at station 0028, due almost entirely to the absence of the grazer fauna. The species present were mainly those associated with fine sediments, and sediment feeders, both surface and infauna (oligochaetes, Tanytarsus, Paratanytarsus, and Pisidium spp.) comprised most (65%) of the fauna.

Station 0050, also an area of mainly sandy substrate, was similarly low in sediment organic matter. Located in a bay west of Sault Ste. Marie, the area appeared to be a depositional area for coarse detritus, since a large segment of the fauna was comprised of species associated with coarse organic matter, such as Endochironomus, Amnicola limosa, and Hyalella azteca. These comprised 38% though the sediment fine particle feeders formed the major fraction (59%). Predators comprised the remaining 3%. The fine particle feeders consisted of such species as Hexagenia limbata, the clam Pisidium walkeri, and the oligochaetes Aulodrilus pleuriseta and Quistadrilus multisetosus, none of which are identified with polluted conditions.

Station 0049 was located in a bay at the west end of Sault Ste. Marie, next to the Algoma Steel mill. Sediments were mainly sand (52%) with some silt and clay (27% and 17% respectively). The benthic fauna however was extremely reduced in both density and diversity and only a small population of Hexagenia limbata and oligochaetes was present. Sediment data indicate that the fauna here should have been similar to preceding areas, with possibly a slightly greater percentage of fine sediment feeders. Though contaminant levels were high, these were not the highest recorded in the river and were an unlikely cause by themselves for the depauperate fauna. The high silt content, as noted, was also likely responsible for only some of the reduction in density and diversity. This was evident at stations further downstream, such as 0045 and 0047, where silt content was high and the resulting faunal diversity and density were reduced. Though no apparent chemical factor could be pinpointed, an external affect was definitely evident, since all other factors tested could not have accounted for this result. This area therefore bears further investigation.

Station 0048, located along the Sault Ste. Marie waterfront had a

similarly reduced fauna, as well as very similar physical sediment characteristics. Organic content was very high, though this may have been a consequence of the high levels of solvent extractables in the sediments. Levels of other contaminants, while high, were not particularly elevated. Levels have been higher in some of the other areas in the Great Lakes (see Sections 3 and 5) though those all occurred in areas of much harder water, and, in the Toronto Waterfront at least, in areas of much higher clay content. The low clay content could make more of the contaminants available to the sediment infauna, since a greater percentage of the metals resident in the fine-grained fraction (see discussion in section 3.1.1) should theoretically reside in the silt. Only a small population of oligochaetes was present and the species were not indicative of organic pollution which implies other chemical factors were involved.

Station 0075 was characterized by a substrate lower in organic content. On the basis of organic content, the sand fraction would have been moderately high (grain size data were lacking) and the benthic fauna was considerably more diverse than the preceding two stations. Density had increased at this station by approximately 10 times over density at station 0048 and nearly 50 times over station 0049. Much of this increase appeared due to the epibenthic grazers, specifically Lirceus lineatus, which alone comprised 46% of the benthic fauna. In addition, both fine sediment feeders (oligochaetes), and predators (Polycentropus and Procladius) were present, though in relatively low numbers. Both groups were conspicuously absent from the previous two stations.

Station 0047 was also a mixed substrate of sand and silt (43% : 50%) of high organic content. The benthic fauna, though present in relatively high density, showed less diversity than station 0075. Sediment fine particle feeders comprised most of the fauna and the sediment infauna (oligochaetes) alone comprised 78% of the fauna, despite the relatively high contaminant levels in the sediments.

Station 0046, also high in silt content (62% silt : 30% sand) was relatively lower than station 0047 in organic content. Density of organisms was high, especially among the chironomids, which comprised nearly half of the fauna. The majority of the fauna was comprised of soft sediment fine particle feeders, of which Chironomus thummi and Dicrotendipes comprised (86%). The predator Procladius made up the other large group (7.6%), while grazers such as Endochironomus and Hexagenia limbata comprised the remaining 6.5%. Among the oligochaetes, Limnodrilus hoffmeisteri comprised most of the fauna, and both this and the chironomid fauna reflected the higher silt content of the sediments.

Station 0044 was situated in an erosional area high in sand content (94%). Organic content and contaminant levels were low and compared well with similar areas upstream (station 0078 and 0050). Despite the substrate type, and the low organic content, sediment fine particle feeders, such as Chironomus and the oligochaete population, comprised over 93% of the fauna, with these two groups alone comprising 90%. Apparently, much of the detritus here existed as fine rather than coarse material, differing from the other two sandy stations (0078 and 0051) upstream.

Station 0045 was in an area high in silt (69%) and, like station 0046, in a depositional area. Sediment organic content was moderately high and contaminant levels were also high. Density and diversity of benthic organisms was somewhat reduced at this station, with sediment fine particle feeders comprising only a minor part of the fauna. Grazers on coarse detritus such as Hyalella azteca, Lirceus lineatus, and Endochironomus, comprised the major part of the fauna (66%). Sediment conditions, perhaps due to the very high silt content (which tends to suffocate many animals, depending on the other constituents of the sediments), were not particularly suited to the sediment infauna.

In summary, upstream areas (stations 0078, 0051, and 0050) yielded diverse faunas representing a number of feeding groups. In contrast, stations 0049 and 0048, at the Algoma Steel Mill and along the Sault Ste. Marie waterfront had severely reduced faunas that could not be explained simply by sediment type. In fact, the opposite occurred, with sediment characteristics indicating that this area should have yielded a fauna similar to upstream locations. Sandy areas within this same zone actually yielded greater densities and higher diversity of organisms than these organically richer areas. A gradual improvement in density and diversity of the benthic fauna appeared to take place with increasing distance downstream from Sault Ste. Marie.

Though contaminant levels, especially solvent extractables and some of the metals, were high at stations 0049 and 0048, evidence from other, contaminated areas, such as the Toronto Waterfront indicated these were not likely the sole cause of the depauperate benthic community, though water hardness and sediment clay content did differ between these two areas. This area therefore bears further investigation to pinpoint the cause or causes.

Summary

1) Areas upstream of Sault Ste. Marie yielded diverse benthic communities which appeared to be affected mainly be substrate type and sediment organic content. Benthic communities in the mainly shallow areas appeared eutrophic but not polluted.

2) Benthic communities at Sault Ste. Marie (stations 0049 and 0048) were severely reduced in both density and diversity. Sediments were similar to upstream areas, and under normal circumstances could have been expected to have similar benthic communities. Contaminant levels were high, though these did not appear to be high enough to have such a severe effect upon the fauna. Presumably other, or additional, factors were also affecting the benthic community.

3) More normal conditions appeared to prevail downstream, and sediment type again seemed to be the main factor affecting the benthic community.

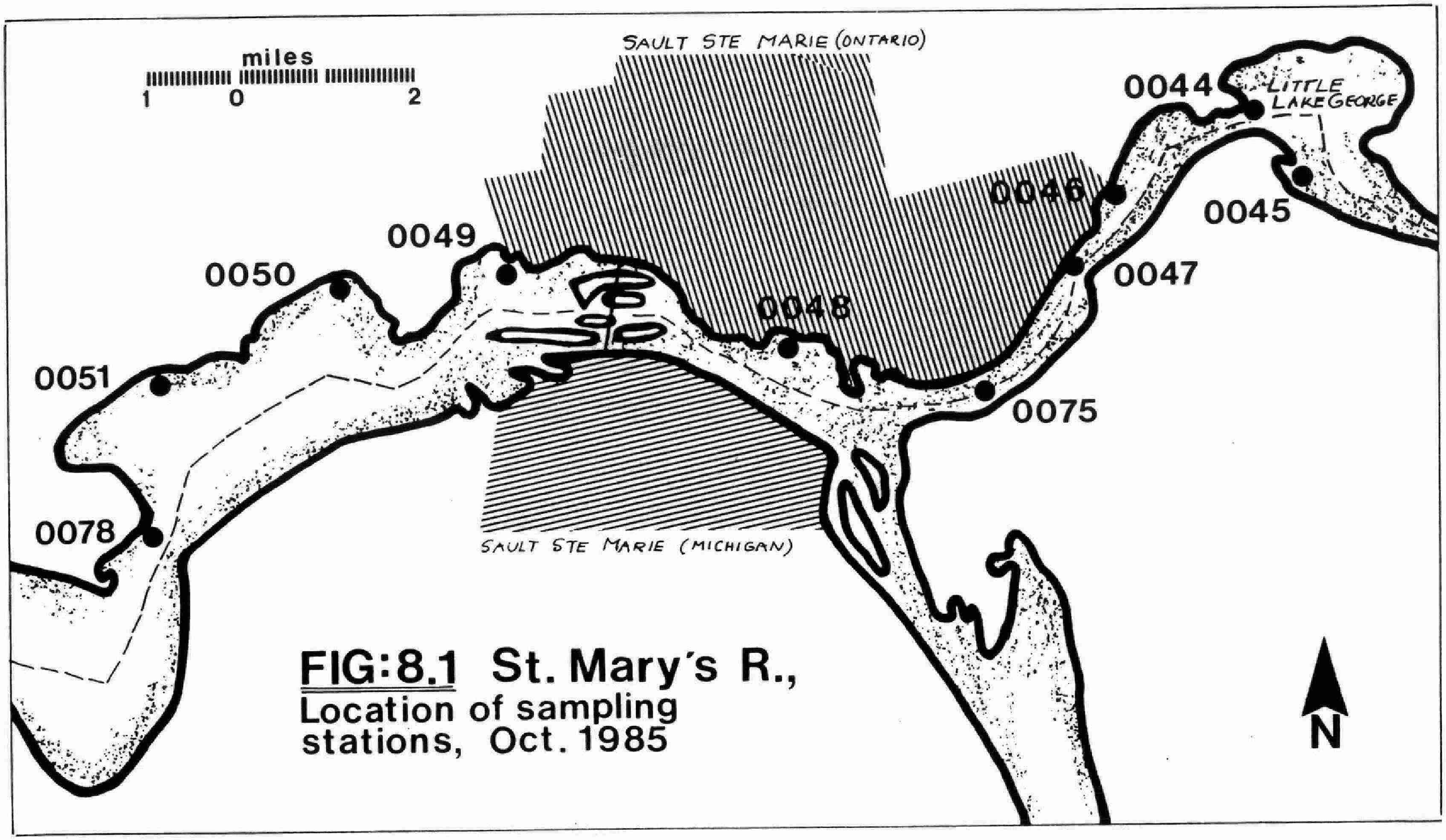

FIG:8.1 St. Mary's R.,
Location of sampling stations, Oct. 1985

TABLE 8.1. WATER QUALITY DATA - ST. MARYS RIVER (TAKEN 1 M OFF BOTTOM).

Station Number	pH	Hardness (mg/l)	Chemical Oxygen Demand (COD) (mg/l)	Dissolved Organic Carbon (DOC) (mg/l)	Total Kjeldahl Nitrogen (TKN) (mg/l)	Turbidity	Suspended Particulate (mg/l)	Sodium (Na) (mg/l)	Chloride (Cl) (mg/l)
0078	7.93	44.0	6.3	1.4	0.100	0.38	4.19	1.43	0.42
0051	8.06	44.5	5.4	1.4	0.100	0.44	5.33	1.39	1.28
0050	7.84	44.5	6.9	1.6	0.190	7.30	-	1.45	1.32
0049	7.89	46.0	5.8	1.4	0.220	1.23	3.07	1.56	1.28
0048	7.87	44.0	6.0	1.4	0.210	0.66	3.21	1.42	1.45
0075	7.89	44.5	6.5	1.3	0.160	0.60	5.17	1.41	1.30
0047	7.99	44.5	5.1	1.4	0.300	2.10	7.53	1.56	2.31
0046	7.88	43.5	4.9	1.3	0.230	1.29	1.36	1.54	1.70
0044	7.87	43.0	6.0	1.3	0.210	1.28	5.62	1.45	1.76
0045	7.88	44.0	6.3	1.3	0.180	0.54	1.73	1.40	1.77

TABLE 8.2. SEDIMENT DATA - ST. MARYS RIVER.

Station Number	Grain Size (%) Gravel/Sand/Silt/Clay	Total Organic Carbon (TOC) (mg/g)	Loss on Ignition (LOI) (%)	Total Phosphorus (TP) (mg/g)	Total Kjeldahl Nitrogen (TKN) (mg/g)	Solvent Extractables (ug/g)
0078	-	5.70	0.87	0.20	0.4	560.0
0051	-	9.00	3.30	0.21	0.4	1,013.0
0050	0/76/18/2	5.30	0.80	0.30	0.6	356.0
0049	0/53/28/18	74.00	9.10	0.39	0.6	2,228.0
0048	0/51/45/3	130.00	19.00	0.58	2.2	14,506.0
0075	-	44.00	6.10	0.47	2.1	5,434.0
0047	0/43/51/5	84.00	10.00	1.00	2.8	10,170.0
0046	0/30/62/7	37.00	6.20	0.40	2.9	2,373.0
0044	0/95/4/1	< 5.00	0.46	0.21	0.3	517.0
0045	1/17/69/13	78.00	11.00	0.65	4.8	13,206.0

Station Number	Cu (ug/g)	Cr (ug/g)	Hg (ug/g)	Fe (ug/g)	As (ug/g)	Zn (ug/g)	Al (ug/g)	Total PCB's (ug/kg)
0078	6.90	8.60	< 0.01	7,000.0	2.13	17.0	2,900.0	< 20
0051	3.00	5.30	< 0.01	4,500.0	1.93	14.0	1,900.0	< 20
0050	3.90	9.50	< 0.01	7,100.0	1.93	20.0	3,700.0	< 20
0049	22.00	42.00	0.09	67,000.0	25.40	580.0	11,000.0	< 20
0048	88.00	110.00	0.35	93,000.0	27.50	440.0	8,700.0	75
0075	46.00	47.00	0.11	31,000.0	10.70	150.0	9,200.0	< 20
0047	100.00	100.00	0.41	79,000.0	12.40	340.0	9,300.0	105
0046	21.00	23.00	0.05	13,000.0	4.06	85.0	7,500.0	< 20
0044	7.00	11.00	0.01	8,700.0	1.86	45.0	2,900.0	< 20
0045	68.00	60.00	0.16	38,000.0	12.50	270.0	13,000.0	< 20

TABLE 8.3. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA - ST. MARYS RIVER.

All values are expressed as #'s per square meter.

	Station #0078		Station #0051		Station #0050	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera	184}	0.1968	347	0.7492	79	0.8821
O. Plecoptera	82}					
O. Odonata						
O. Trichoptera	128	0.0586	31	0.0085	139	0.1505
O. Diptera						
F. Chironomidae	3,876	2.1390	700	0.1409	1,213	1.0222
F. Ceratopogonidae	56	0.0046	5		41	0.0625
O. Megaloptera			36	0.0552	43	0.1192
O. Hemiptera	5	0.0046				
O. Lepidoptera						
Class Arachnida						
O. Acarina	31	0.0182	5		8	0.0081
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	1,512	0.3862	10	0.0054	437	0.1038
O. Isopoda	6,393	9.720			8	0.0069
O. Decapoda						
MOLLUSCA						
Class Gastropoda	408	17.9902	15	0.0597	217	0.7852
Class Pelecypoda	858	6.3708	56	0.0031	184	0.0177
NEMATODA			5			
PLATYHELMINTHES						
Class Turbellaria	41	0.0064			18	0.0012
ANNELIDA						
Class Hirudinea	41	0.0824				
Class Oligochaeta	1,966	1.8516	179	0.0237	858	0.3662
TOTAL # ORGANISMS	15,581		1,389		2,851	
TOTAL BIOMASS		38.8294		1.0457		3.5256
CORRECTED BIOMASS (+10%)		42.7123		1.1503		3.8782

TABLE 8.3. (Continued)

All values are expressed as #'s per square meter.

	Station #0049		Station #0048		Station #0075	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera						
O. Plecoptera						
O. Odonata					8	
O. Trichoptera					69	0.0161
O. Diptera						
F. Chironomidae			5	0.0008	437	0.1034
F. Ceratopogonidae						
O. Megaloptera						
O. Hemiptera						
O. Lepidoptera					8	0.0298
Class Arachnida						
O. Acarina						
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda					130	0.0459
O. Isopoda					789	0.7802
O. Decapoda					8	
MOLLUSCA						
Class Gastropoda					100	0.0724
Class Pelecypoda					61	0.0862
NEMATODA						
PLATYHELMINTHES						
Class Turbellaria						
ANNELIDA						
Class Hirudinea					15	0.2275
Class Oligochaeta	29	0.0087	156	0.1268	245	0.4022
TOTAL # ORGANISMS	29		161		1,870	
TOTAL BIOMASS		0.0087		0.1276		1.7637
CORRECTED BIOMASS (+10%)		0.0096		0.1404		1.9401

TABLE 8.3. (Continued)

All values are expressed as #'s per square meter.

Station #0047		Station #0046		Station #0044		Station #0045	
Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
						1	
54	0.0391	1,586	0.9767	2,078	1.8522	235	0.0171
		54	0.0827	15	0.02145		
		23	0.0299	5	0.0016		
8		153	0.0793	10		135	0.0219
23	0.1046	8	0.0035	41		423	1.7104
						3	17.6390
1,011	2.1509	46	0.0242	255	0.2314	45	0.0383
						1	
		8	0.0149	10		4	
		46	0.6515	20	0.93758	1	
3,174	1.8086	1,907	0.8296	4,361	4.9974	37	0.0026
4,290		3,831		6,795		885	
	4.1032		2.6923		8.0416		19.4293
	4.5135		2.9615		8.8458		21.3722

TABLE 8.4. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - ST. MARYS RIVER.

	STATION NUMBER (#/m²)									
SPECIES	0078	0051	0050	0049	0048	0075	0047	0046	0044	0045
EPHEMEROPTERA:										
Ephemeridae:										
Ephemera simulans	184									
Hexagenia limbata			352	61						
Caenidae:										
Caenis sp.		92								
PLECOPTERA										
Perlodidae:										
Isoperla sp.	61									
TRICHOPTERA										
Leptoceridae:										
Mystacides sepulchralis		15	15							4
Triaenodes sp.	31									
Polycentropodidae:										
Polycentropus sp.			230			92				
Phylocentropus sp.		15								
ODONATA										
Coenagrionidae:										
sp. indet.						23				
MEGALOPTERA										
Sialidae:										
Sialis sp.		15	31							
LEPIDOPTERA										
Munroessa sp.								46	31	
DIPTERA										
Ceratopogonidae:										
Palpomyia complex	92	15	15							
Chironomidae:										
Chironomus thummi group	61							545	2,604	
Cryptochironomus sp.		153							61	
Demicryptochironomus sp.	61	31								
Dicrotendipes sp.	61	92	475					597	153	73
Endochironomus sp. 1	832		153		4	23		184		11
Endochironomus sp. 2			551							
Glyptotendipes sp.			107							
Pagastiella sp.		61								
Paratanytarsus sp.	306	322								
Tanytarsus sp.		245	77							
Monodiamesa sp.	61									
Potthastia longimana	61									
Cricotopus sp.										11
Orthocladius sp.			46							
Ablabesmyia sp.		61								
Procladius sp.	398	123	123		4	46	69	368	184	
Thienemannimyia group	153					207				88
Psectrocladius sp.								23		
Polypedilum sp.	3,072									
AMPHIPODA										
Talitridae:										
Hyalella azteca	1,685		550			161	23	138	31	165
ISOPODA										
Asellidae:										
Asellus sp.	1,746						46			77
Lirceus lineatus	5,270		15			758			123	257
DECAPODA										
Orconectes propinquus						23				4
GASTROPODA										
Physidae:										
Physella gyrina sayi	184		31					23		
Hydrobiidae:										
Amnicola limosa	368		322						398	11
Planorbidae:										
Helisoma sp.	153						368			
Gyralus parvus						46	115	92	153	
Promenetus exacuous										15

TABLE 8.4. DENSITY AND DISTRIBUTION OF MACROBENTHIC TAXA - ST. MARYS RIVER. (Continued)

SPECIES	STATION NUMBER (#/m²) 0078	0051	0050	0049	0048	0075	0047	0046	0044	0045
Valvatidae:										
Valvata sincera	31								61	
V. tricarinata							23		61	
Ancylidae:										
Ferrissia sp.										15
PELECYPODA										
Sphaeriidae:										
Sphaerium sp.	123	15								
Pisidium casertanum		123	414			23				
P. walkeri	61									
P. ventricosum	31									
HIRUDINEA										
Helobdella sp.								23	31	
Mooreobdella sp.								46		
Glossiphonia complanata										4
OLIGOCHAETA										
Enchytraeidae:										
sp. indet.	61	77	46	8		46	1,471		797	
Naididae:										
sp. indet.										4
Amphichaeta sp.					4					
Dero sp.	153					46	437		398	
Piguetiella michiganensis		61								
Tubificidae:										
Aulodrilus pleuriseta			153			115	299			
Quistadrilus multisetosus		31	597	8						
Potamothrix vejdovskyi					23					
P. moldaviensis	61									
Limnodrilus hoffmeisteri							138	483	797	
L. angustipenis					4					
Immatures with capilliform setae	123	138	245		23					
Immatures without capilliform setae	214		92	23	46	46		2,459	7,292	27
Total Number of Organisms	15,698	2,037	4,349	39	108	1,655	2,989	4,827	13,175	766
Species Diversity (H')	3.21	3.78	3.81	1.37	2.16	2.78	2.32	2.43	2.20	2.84
Species Richness (S.R.)	3.42	3.18	2.99	0.87	1.80	2.14	1.35	1.68	1.84	2.64
Evenness (J')	0.66	0.86	0.85	0.86	0.77	0.73	0.70	0.65	0.55	0.72

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